

**FREE  
PIC TUTORIAL V2  
SUPPLEMENT**

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY

Vol.32 No.4

# PRACTICAL ELECTRONICS

CAN \$6.99/US \$4.95

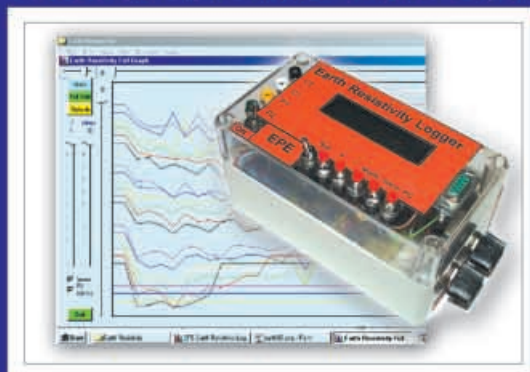
**FREE  
INSIDE!**

## EPE PIC TUTORIAL V2 Part 1 - Special 16 Page Supplement

The best introduction to  
using PIC microcontrollers

## EARTH RESISTIVITY LOGGER

See beneath the soil



## ATMOSPHERICS MONITOR

Tune in to the sounds  
of the heavens

**PLUS  
BACK TO BASICS 3  
Two easy to build projects**



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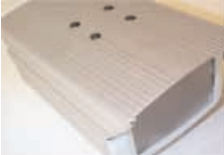




Colour CCTV camera, 8mm lens, 12V d.c. 200mA 582x628 Resolution 380 lines Automatic aperture lens Mirror function PAL Back Light Compensation MLR, 100x40x40mm. Ref EE2 £69



Built-in Audio .15lux CCD camera 12V d.c. 200mA 480 lines s/n ratio >48db 1v P-P output 110x60x50mm. Ref EE1 £99



Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in. Available in two sizes 1 - 100x10x170mm and 2 - 100x70x280mm. Ref EE6 £22 EE7 £26 multi-position brackets. Ref EE8 £8



Excellent quality multi-purpose TV/TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV. Ideal for use in boats and caravans 49.7MHz-91.75MHz VHF channels 1-5, 168.25MHz-222.75MHz VHF channels 6-12, 471.25MHz-869.75MHz, Cable channels 112.325MHz-166.75MHz Z1-Z7, Cable channels 224.25MHz-446.75MHz Z8-Z35 5" colour screen. Audio output 150mW. Connections, external aerial, earphone jack, audio/video input, 12V d.c. or mains, Accessories supplied Power supply, Remote control, Cigar lead power supply, Headphone Stand/bracket. 5" model £139 Ref EE9, 6" model £149. Ref EE10



Fully cased IR light source suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra-red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical usage would be to provide additional IR illumination for CCTV cameras. £49. Ref EE11



This device is mains operated and designed to be used with a standard CCTV camera causing it to scan. The black clips can be moved to adjust the scan angle, the motor reversing when it detects a clip. With the clips removed the scanner will rotate constantly at approx 2.3rpm. 75x75x80mm £23. Ref EE12



Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR LEDs .2 lux 12 IR LEDs 12V d.c. Bracket Easy connect leads £69. Ref EE15



A high quality external colour CCTV camera with built in Infra-red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4" CCD 542x588 pixels 420 lines .05 lux 3.6mm F2.78 deg lens 12V d.c. 400mA Built in light level sensor. £99. Ref EE13



A small compact colour CCTV camera measuring just 35x28x30mm (camera body) Camera is supplied complete with mounting bracket, built in IR, microphone and easy connect leads. Built in audio Built in IR LEDs Colour 380 line resolution PAL 0.2 us +18db sensitivity. Effective pixels 628x582 Power source 6-12V d.c. Power consumption 200mW £36. Ref EE16



Complete wireless CCTV system with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4GHz 3 lux 6-12V d.c. manual tuning Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £79 (standard). Ref EE18



Small transmitter designed to transmit audio and video signals on 2.4GHz. Unit measures 45x35x10mm. Ideal for assembly into covert CCTV systems Easy connect leads Audio and video input 12V d.c. Complete with aerial Selectable channel switch £30. Ref EE19



2.4GHz wireless receiver Fully cased audio and video 2.4GHz wireless receiver 190x140x30mm, metal case, 4 channel, 12V d.c. Adjustable time delay, 4s, 8s, 12s, 16s. £45. Ref EE20



Colour pinhole CCTV camera module with audio Compact colour pinhole camera measuring just 20x20x20mm, built-in audio and easy connect leads PAL CMOS sensor 6-9V d.c. Effective Pixels 628x582 Illumination 2 lux Definition >240 Signal/noise ratio >40db Power consumption 200mW £35. Ref E35



Self-cocking pistol plcr002 crossbow with metal body. Self-cocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy. Adjustable rearsight 50lb drawweight 150ft sec velocity Break action 17" string 30m range £21.65 Ref PLCR002 **INFRA-RED FILM** 6" square piece of flexible infra-red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra-red output only using standard light bulbs Easily cut to shape. 6" square £15. Ref IRF2 or a 12" sq for £29 IRF2A **NEW 12V 12" SQUARE SOLAR PANEL** Kevlar backed, 3watt output. Copper strips for easy solder connections £14.99. Ref 15P42 **PACK OF 4 JUST £39.95. REF 15P42SP**



Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with rawl plugs and fixing screws. Camera also has a flashing red LED built in. £9.95. Ref CAMERAB

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Aiptek Pocket DV Up to 2000 still pics before requiring download!! The all new Pocket DV, it's amazing ... such advanced technology, such a tiny size - you will be the envy of your friends!! This camera will take up to 3.5 minutes of Video and Audio, up to 2000 digital still pictures or 30 minutes of voice recording!! Then just connect it to your PC via the USB cable (Supplied) and after transferring the data you can start all over again!! £69. Ref POCKETDV



The smallest PMR446 radios currently available (54x87x37mm). These tiny handheld PMR radios not only look great, but they are user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £59.99 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: ~35 hours Includes: ~2 x Radios, 2 x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £84.99. Ref Alan2



Beltronics BEL550 Euroradarand GATSO detector Claimed Detection Range: GATSO up 400m. Radar & Laser guns up to 3 miles. Detects GATSO speed cameras at least 200 metres away, plenty of time to adjust your speed £319. Ref BEL550



Fully Portable - Use anywhere Six automatic programmer for full body pain relief, shoulder pain, back/neck pain, aching joints, rheumatic pain, sports injuries EFFECTIVE DRUG FREE PAIN RELIEF TENS (Transcutaneous Electrical Nerve Stimulation) units are widely used in hospitals, clinics throughout the United Kingdom for effective drug free pain relief. This compact unit is now approved for home use. TENS works by stimulating nerves close to the skin releasing endorphins (nature's anaesthetics) and helping to block the pain signals sent to the brain. Relief can begin within minutes, and a 30 minute treatment can give up 12 hours relief or more. The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £19.95 Ref TEN327 Spare pack of electrodes £5.99. Ref TEN327X

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### FREE SUPPLEMENT

- EPE PIC TUTORIAL V2 – Part 1** **between pages 268 and 269**  
Quite simply the best low-cost way to learn about using PICs! An enhanced revision of our highly acclaimed series of 1998.

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Our May 2003 issue will be published on Thursday, 10 April 2003. See page 235 for details

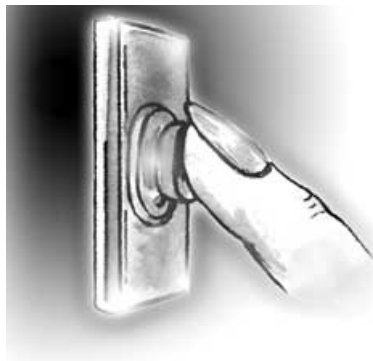
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# NEXT MONTH

FREE  
SUPPLEMENT  
PIC TUTORIAL V2  
Part 2

## DOOR CHIME

Recreate the nostalgic "Ding Dong" chime with this design. Employs a handful of active components, including a power amplifier i.c., to give a realistic chime sound from a small p.c.b. supplied by a 9V PP3 battery. The note frequencies can be altered to meet individual preferences.



## SUPER MOTION SENSOR

This relatively simple unit – it employs just three i.c.s and a couple of transistors – will detect a single finger moving at a distance of five metres, or a person crossing a path at 20 metres. The circuit responds to fluctuations in light level and is thus much more flexible than a typical "light beam" system. Requiring no setting up, the unit auto-adjusts over the range of about 50 lux to 60,000 lux and it can thus be used without a dedicated light source in a wide variety of daylight situations, or with virtually any a.c. lighting source.

PLUS

## BACK TO BASICS

**Live Wire Detector and MW Radio.**

**Two more simple, easy to build projects.**

The Live Wire Detector uses just six components to detect live mains wires, to locate breaks in mains circuits and to test light bulbs, fuses and relay coils for continuity. Another three transistor project, the MW Radio is a simple regenerative design that is fun to build and use.

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## PROJECT KITS

Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

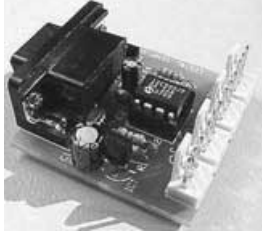
- **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x75mm. **1046KT £24.95**
- **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handling 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £24.95**
- **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACs. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £15.95; BOX (for mains operation) £26.95**
- **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency. 1-60Hz. Mains powered. PCB: 60x68mm. Box provided. **6037KT £28.95**

- **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £5.95**
- **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**
- **IR REMOTE TOGGLE SWITCH** Use any TV/VCr remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**
- **SPEED CONTROLLER** for any common DC motor up to 100W/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**
- **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 6 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

## PRODUCT FEATURE

### COMPUTER TEMPERATURE DATA LOGGER

PC serial port controlled 4-channel temperature meter (either deg C or F). Requires no external power. Allows continuous temperature data logging of up to four temperature sensors located 200m+ from motherboard/PC. Ideal use for old 386/486 computers. Users can tailor input data stream to suit their purpose (dump it to a spreadsheet or write your own BASIC programs using the INPUT command to grab the readings). PCB just 38mm x 38mm. Sensors connect via four 3-pin headers. 4 header cables supplied but only one DS18S20 sensor. Kit software available free from our website. **ORDERING: 3145KT £23.95 (kit form); AS3145 £29.95 (assembled); Additional DS18S20 sensors £4.95 each**



- **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x55mm. **1045KT £8.95**
- **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £8.95**
- **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**
- **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**
- **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131KT £12.95**
- **TRAIN SOUNDS** 4 selectable sounds: whistle blowing, level crossing bell, 'clackety-clack' & 4 in sequence. **SG01M £8.95**

- **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory. Each relay output is capable of switching 250VAC/4A. A suite of DOS and Windows control programs are provided together with all components (except box and PC cable). 12VDC. PCB 70x200mm. **3074KT £31.95**
- **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**
- **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**
- **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**
- **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**
- **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**
- **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexer. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10µs. Software (C, CB & Win), extended D shell case & all components (except sensors & cable) provided. **3118KT £52.95**

- **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080KT £5.95**
- **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**
- **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to

## SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/clip. All transmitters can be received on an ordinary VHF-FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

### ROOM SURVEILLANCE

- **MTX - MINIATURE 3V TRANSMITTER** Easy to build & guaranteed to transmit 300m @ 3V. Long battery life. 3-5V operation. Only 45x11mm. **B 3007KT £6.95 AS3007 £11.95**
- **MRTX - MINIATURE 9V TRANSMITTER** Our best selling bug. Super sensitive, high power - 500m range @ 9V (over 1km with 18V supply and better aerial). 45x19mm. **3018KT £7.95 AS3018 £12.95**
- **HPXT - HIGH POWER TRANSMITTER** High performance, 2 stage transmitter gives greater stability & higher quality reception. 1000m range 6-12V DC operation. Size 70x15mm. **3032KT £9.95 AS3032 £18.95**
- **MMTX - MICRO-MINIATURE 9V TRANSMITTER** The ultimate bug for its size, performance and price. Just 15x25mm. 500m range @ 9V. Good stability. 6-18V operation. **3051KT £8.95 AS3051 £14.95**
- **VTX - VOICE ACTIVATED TRANSMITTER** Operates only when sounds detected. Low standby current. Variable trigger sensitivity. 500m range. Peaking circuit supplied for maximum RF output. On/off switch. 6V operation. Only 63x39mm. **3028KT £12.95 AS3028 £24.95**
- **HARDWIRED BUG/TWO STATION INTERCOM** Each station has its own amplifier, speaker and mic. Can be set up as either a hard-wired bug or two-station intercom. 10m x 2-core cable supplied. 9V operation. **3021KT £15.95 (kit form only)**
- **TRVS - TAP RECORDER VOX SWITCH** Used to automatically operate a tape recorder (not supplied) via its REMOTE socket when sounds are detected. All conversations recorded. Adjustable sensitivity & turn-off delay. 115x19mm. **3019KT £9.95 AS3019 £21.95**

### TELEPHONE SURVEILLANCE

- **MTX - MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £8.95 AS3016 £14.95**
- **TR - TELEPHONE RECORDING INTERFACE** Automatically records all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £9.95 AS3033 £18.95**
- **TPA - TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line and hear phone eavesdrop and hear both sides of the conversation. **3055KT £11.95 AS3055 £20.95**

### HIGH POWER TRANSMITTERS

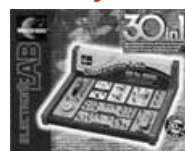
- **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two-stage circuit. Kit includes microphone and requires a simple open dipole aerial. 8-30VDC. PCB 42x45mm. **1098KT £12.95**
- **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT £22.95 AS1028 £34.95**
- **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole, Ground Plane, 5B, J, or YAGI antennas. 12-18VDC. PCB 70x220mm. SWR meter needed for alignment. **1021KT £9.95**
- **SIMILAR TO ABOVE BUT 25W Output.** **1031KT £109.95**

- 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £17.95**
- **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm. **1052KT £16.95**
- **NEGATIVE/POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**
- **LED DICE** Classic intro to electronics & circuit analysis. 7 LEDs simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**
- **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**
- **ROULETTE LED 'Ball'** spins round the wheel, slows down & drops into slot. 10 LEDs. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**
- **12V XENON TUBE FLASHER TRANSFORMER** steps up a12V supply to flash a 25mm Xenon tube. Adjustable flash rate. **3163KT £13.95**
- **LED FLASHER 1** 5 ultra bright red LEDs flash in 7 selectable patterns. **3037MKT £5.95**
- **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**
- **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £21.95**
- **SERIAL PIC PROGRAMMER** for all 818/28/40 pin DIP serial programmed PICs. Shareware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £10.95**
- **ATMEL 89C051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C051, 89C2051 & 89C4051 uCs. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**
- **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**
- **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £16.95.**

- **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £27.95.**
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- **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm. **1019KT £11.95 Box 2019BX £8.00**
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- **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3100KT £12.95**
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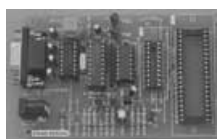
## Enhanced 'PICALL' ISP PIC Programmer

Kit will program virtually ALL 8 to 40 pin\* serial and parallel programmed PIC micro-controllers. Connects to PC parallel port. Supplied with fully functional pre-registered PICALL DOS and WINDOWS AVR software packages, all components and high quality DSPTH board. Also programs certain ATMEL AVR, SCENIX SX and EEPROM 24C devices. New devices can be added to the software as they are released. Blank chip auto detect feature for super-fast bulk programming. Hardware now supports ISP programming. \*A 40 pin wide ZIF socket is required to program 0-3in. devices (Order Code AZIF40 @ £15.00).



Order Ref	Description	inc. VAT ea
3144KT	Enhanced 'PICALL' ISP PIC Programmer	£59.95
AS3144	Assembled Enhanced 'PICALL' ISP PIC Programmer	£64.95
AS3144ZIF	Assembled Enhanced 'PICALL' ISP PIC Programmer c/w ZIF socket	£79.95

## ATMEL AVR Programmer



Powerful programmer for Atmel AT90Sxxxx (AVR) micro controller family. All fuse and lock bits are programmable. Connects to serial port. Can be used with ANY computer and operating system. Two LEDs to indicate programming status. Supports 20-pin DIP AT90S1200 & AT90S2313 and 40-pin

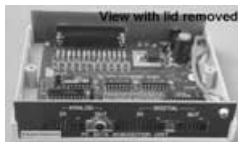
DIP AT90S4414 & AT90S8515 devices. NO special software required – uses any terminal emulator program (built into Windows). The programmer is supported by BASCOM-AVR Basic Compiler software (see website for details).

Order Ref	Description	inc. VAT ea
3122KT	ATMEL AVR Programmer	£24.95
AS3122	Assembled 3122	£34.95

Atmel 89C051 and 89xxx programmers also available.

## PC Data Acquisition & Control Unit

With this kit you can use a PC parallel port as a real world interface. Unit can be connected to a mixture of analogue and digital inputs from pressure, temperature, movement, sound, light intensity, weight sensors, etc. (not supplied) to sensing switch and relay states. It can then process the input data and use the information to control up to 11 physical devices such as motors, sirens, other relays, servo motors & two-stepper motors.



### FEATURES:

- 8 Digital Outputs: Open collector, 500mA, 33V max.
  - 16 Digital Inputs: 20V max. Protection 1K in series, 5-1V Zener to ground.
  - 11 Analogue Inputs: 0-5V, 10 bit (5mV/step.)
  - 1 Analogue Output: 0-2.5V or 0-10V. 8 bit (20mV/step.)
- All components provided including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo) with screen printed front & rear panels supplied. Software utilities & programming examples supplied.

Order Ref	Description	inc. VAT ea
3093KT	PC Data Acquisition & Control Unit	£99.95
AS3093	Assembled 3093	£124.95

**See opposite page for ordering information on these kits**

## ABC Mini 'Hotchip' Board

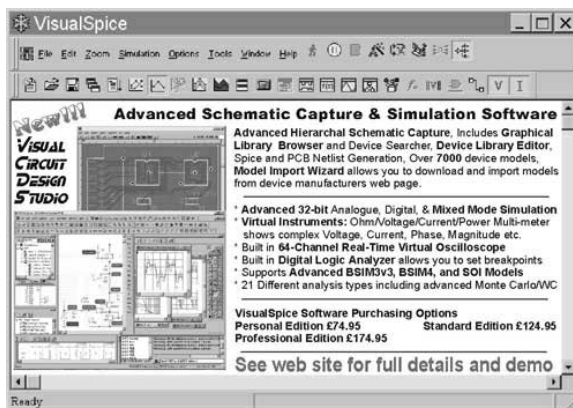


Currently learning about microcontrollers? Need to do something more than flash a LED or sound a buzzer? The ABC Mini 'Hotchip' Board is based on Atmel's AVR 8535 RISC technology and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the BASIC programming language, within an hour or two of connecting it up.

Experts will like the power and flexibility of the ATMEL microcontroller, as well as the ease with which the little Hot Chip board can be "designed-in" to a project. The ABC Mini Board 'Starter Pack' includes just about everything you need to get up and experimenting right away. On the hardware side, there's a pre-assembled micro controller PC board with both parallel and serial cables for connection to your PC. Windows software included on CD-ROM features an Assembler, BASIC compiler and in-system programmer. The pre-assembled boards only are also available separately.

Order Ref	Description	inc. VAT ea
ABCMINISP	ABC MINI Starter Pack	£64.95
ABCMINIB	ABC MINI Board Only	£39.95

## Advanced 32-bit Schematic Capture and Simulation Visual Design Studio



## Serial Port Isolated I/O Controller

Kit provides eight relay outputs capable of switching 4 amps at mains voltages and four optically isolated digital inputs. Can be used in a variety of control and sensing applications including load switching, external switch input sensing, contact closure and external voltage sensing.



Programmed via a computer serial port, it is compatible with ANY computer & operating system. After programming, PC can be disconnected. Serial cable can be up to 35m long, allowing 'remote' control. User can easily write batch file programs to control the kit using simple text commands. NO special software required – uses any terminal emulator program (built into Windows). All components provided including a plastic case with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo).

Order Ref	Description	inc. VAT
3108KT	Serial Port Isolated I/O Controller Kit	£54.95
AS3108	Assembled Serial Port Isolated I/O Controller	£64.95





**80-173** 12V DC motor, flat style, 3000 RPM, 18 NCM torque, draws 5 Amps, reversible, 24 toothed gear. Ideal for robot wars, etc. Dimensions 152mm diameter x 80mm including spindle and gear. Very good quality mounted on a fixing bracket. Some sort of speed counting circuitry on rear. **Bargain at just £19.95**



**80-175** In-line RCD protected powerbreaker. Maximum load 10A @ 250V AC. Reset and test buttons. IEC plug for mains input with an IEC socket on a 1m long lead. These usually sell for around £36.00. **Our price £5.00**

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**56-155** KBPC3501 bridge rectifier. 100V, 35Amp. **£2.50 each**



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**80-132** Switch mode PSU. Nice little unit. Model No. BM43024. Input 120V AC or 240V AC. Output +5V @ 2.5A and +12V @ 2A, 36.5W. Semi-cased with mains IEC filter and switch. **£3.95**



**38-428** USB lead, 2m long, 'A' plug to 'A' plug. **£2.95**

**38-429** USB lead, 2m long, 'A' plug to 'B' plug. **£2.95**

**38-430** USB lead, 2m long, 'B' plug to 'B' plug. **£2.95**



**80-135** Flat pack fan, 12V DC. Made by Papst. Air flows around the blades and out the side to produce a strong air flow. Excellent for cooling down in crowded enclosures. 121 x 121 x 37mm. Ex-equipment but in full working order and excellent condition. These are normally over £25.00 new. **Our price just £5.50**



**42-337** Plastic construction metric dial vernier. Reads 0-100mm. Outside, inside, depth and step measurements. Has a locking device and comes supplied in a neat case. **£7.95**

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**48-259** Ferrite rod with 1 x tuning coil. 140mm long x 10mm diameter. **£1.75**



**80-046** Electronic digital caliper for both imperial (0-6 inches) and metric (0-150mm). Accuracy +/- 0.001". Simple touch button facility to change from metric to imperial (and vice versa). On/off and zero button, inside and outside measuring plus locking screw to hold measurement. Uses a standard watch battery (included). Metal construction. Supplied in a neat plastic storage case. **Special price of £34.95**

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- DUAL OPTION



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A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mains power unit £5.99 extra.

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## ★ TENS UNIT ★

### DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Magenta have prepared a FULL KIT for this excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

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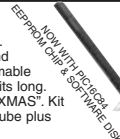
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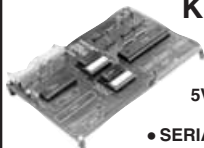
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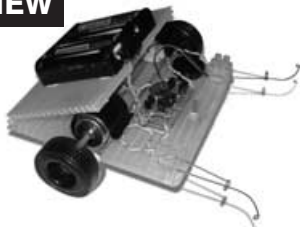
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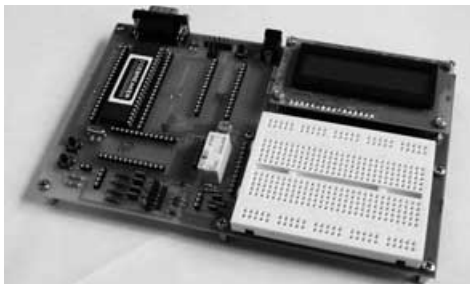
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□□□□□□□□□□



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## 100 AND COUNTING

Over the years we have learned a lot about the needs of readers – suffice to say that the editorial staff on *EPE* have over 100 years of collective experience in this game – we also try to meet those needs and change with them as interests and technology move on. When microcontrollers came along we were one of the first hobbyist magazines in the world to use them (nearly 11 years ago) and, as they have become more and more popular in hobbyist projects, so we have moved along with them. Back in 1998 we published John Becker's *EPE PIC Tutorial* course and now, five years later, we are unashamedly publishing an updated version.

The original Tutorial has been highly acclaimed and thousands of readers have gained the knowledge to write software and program their own PIC microcontrollers from it. Basically it is still a very sound (possibly the best ever – until now, of course) introduction but, as technology and software have moved on in those five years, and because we can now only supply the original series as a set of photocopies (inconvenient for both us and you, the reader), we have decided it is time for an update.

## RESOURCES

To go with the Version 2 series – being published as three 16-page Supplements in the April, May and June issues – we have produced a special *EPE PIC Resources CD-ROM*. This contains not only the V2 Tutorial software for the series, but also the constructional project article (in PDF form) and software for the *PIC Toolkit Mk3* used as the demonstration hardware in the V2 Tutorial (this was originally published in the October and November '01 issues – in case you still have them). We have also included 14 other PIC features and projects (plus software) from past issues of *EPE*, together with four unpublished articles, all on the use and programming of PIC microcontrollers. Whilst we believe the *EPE PIC Resources CD-ROM* will be invaluable to those following the V2 Tutorial, it is not essential as the necessary course software is also available for free download from our website, and photocopies of the *PIC Toolkit Mk3* articles are available from our *Back Issues* department, should you need them. Full details on the *PIC Resources CD-ROM*, plus an order form, can be found elsewhere in this issue, it can also be ordered from the shop on our website.

*Mike Kenward*

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# ATMOSPHERICS MONITOR



BRIAN M. LUCAS

*Tune in to the sounds of the heavens in turmoil!*

WITH the chaotic weather of recent years, have you given any thought to what's going on up there? It is generally known that you can hear on a domestic radio the electrical activity of lightning when a storm is in progress, with the characteristic large *crack* and *swishing* sound, emanating from the speaker and that's about all.

What if you could hear other sounds over a distance of thousands of miles away, such as *Inter Cloud Discharges*, *Sliding Whistles*, *Tweaks*, *Pings*, *Chirps*, *Risers*, *Chinks*, *Clicks*, and the exotic *Dawn Chorus*?

"Has this guy lost his marbles?" Well, no, because indeed you can detect and monitor all these sounds from our atmosphere, from the comfort of your home, using little more than a ferrite rod with a wideband amplifier, and piezoelectric sounder – as you can now discover!

## WHAT IS THIS ACTIVITY?

There are historical accounts linking the earth's ionosphere sounds that go back to the days of early telephone development over long wires. During 19th Century and First World War use, strange sounds emanating from earphones were noted. They became known as Natural Radio, a product of global lightning, producing on average over 44,000 discharges a day.

The most sought after is the elusive Whistler that produces a sliding note, from around 6kHz down to 300Hz, with a duration of between 0.3 and five seconds. This sound is created when a distant lightning strike on the other side of the earth produces a wide spectrum of electrical noise that becomes ducted into the earth's magnetosphere (magnetic field in space). While radiating outward, it combines with the solar wind's ionising charge to create the dispersed and sliding high to low frequency whistle that can be heard with this design in your hemisphere.

Another rarity is the Dawn Chorus, which sounds like a rookery of birds, combining rising whistles, chirping and warbles, produced through the sun ejecting

charged ions that impinge on the earth's magnetosphere, causing the *Northern Lights*, or *Aurora*, seen seasonally from dusk through to dawn in various parts of the northern hemisphere.

Many other short period sounds can be heard like Pings, Hooks, Chirps and Risers; also Chinks and Tweaks. The last two are dampened oscillations from 1.6kHz to 4kHz, throughout the earth's waveguide around the ionosphere's D- and E-layers, 45 to 75 miles above the earth. These create a bell-like resonance that rolls-off sharply around 1.5kHz.

Another sound that can be heard is the Inter-Cloud discharge activity, occurring just as storms build-up, prior to any forked lightning discharges. The excess electrostatic cloud charge reaches its limit, to discharge within the cloud, producing an unusual sound known as "Walking On Broken Glass", variable over a duration of 0.4 to 1.2 seconds.

## WHISTLER'S MOTHER?

The experimental years have been long in developing the Atmospherics Monitor described here. The birth of the idea eventually came to maturity as the circuit shown in Fig.1.

The aerial rod and coil assembly, L1, set the radio frequency reception bandwidth. The incoming amplitude modulated signal is initially a.c. coupled to transistor TR1 and op.amp IC1a. Preset VR1 sets the transistor's bias current and thus the half-rail bias voltage (4.5V) for IC1a. Stage gain is principally set to around  $\times 28$  by resistors R5 and R6.

The bandwidth of this stage is set by capacitors C2 and C5. The frequency response characteristic at IC1b pin 1 is shown in the top curve in Fig.2. The -1dB knee points are 2.3kHz and 9.1kHz, although as the roll-off continues a greater bandwidth extends until the noise floor is reached at -12.5dB, relating to -63dB or 600 $\mu$ V.

Part of this noise is generated by transistor TR1, even though a low noise BC109C is used. The atmospheric background is alive and kicking just below this





**Resistors**

R1, R10	2k2 (2 off)	R8, R9	220k (2 off)
R2, R16	10k (2 off)	R11	47k
R3	100k	R12	15k
R4	270k	R14, R15	22k (2 off)
R5, R13	1k (2 off)	R17	33k
R6	27k	R18, R19	120k (2 off)
R7	150k	R20	5k6

All 0.25W 2% low-noise metal film

**Potentiometers**

VR1	47k or 50k min. round preset
VR2	100k rotary carbon

**Capacitors**

C1, C16	220µ radial elect. 16V (2 off)
C2	10n ceramic disc, 2.5mm pitch
C3, C6,	100n ceramic disc 2.5mm pitch (4 off)
C13, C17	2µ2 radial elect, 16V (2 off)
C4, C10	1µ radial elect, 16V (2 off)
C5, C8	220p ceramic disc, 2.5mm pitch
C7	220n ceramic disc, 2.5mm pitch
C9	560p ceramic disc, 2.5mm pitch
C11	220n ceramic disc, 2.5mm pitch
C12	820p ceramic disc, 2.5mm pitch
C14	22µ radial elect. 16V
C15	22µ radial elect. 16V

**Semiconductors**

D1 to D3	1N4148 signal diode (3 off)
TR1, TR2	BC109C npn transistor (2 off)
IC1, IC2	LM358 dual op.amp (2 off)

**Miscellaneous**

L1	ferrite rod, 200mm x 10mm dia., plus 500 turns 40s.w.g. enamelled copper wire
ME1	250µA panel meter
WD1	resonant piezo sounder, 4-6kHz

Stripboard, 13 strips x 35 holes; plastic case to suit (optional); furniture "foot" to fit WD1; plastic tube to mount L1 – see text; 9V PP3 battery and clip; knob for VR2; solder, etc.

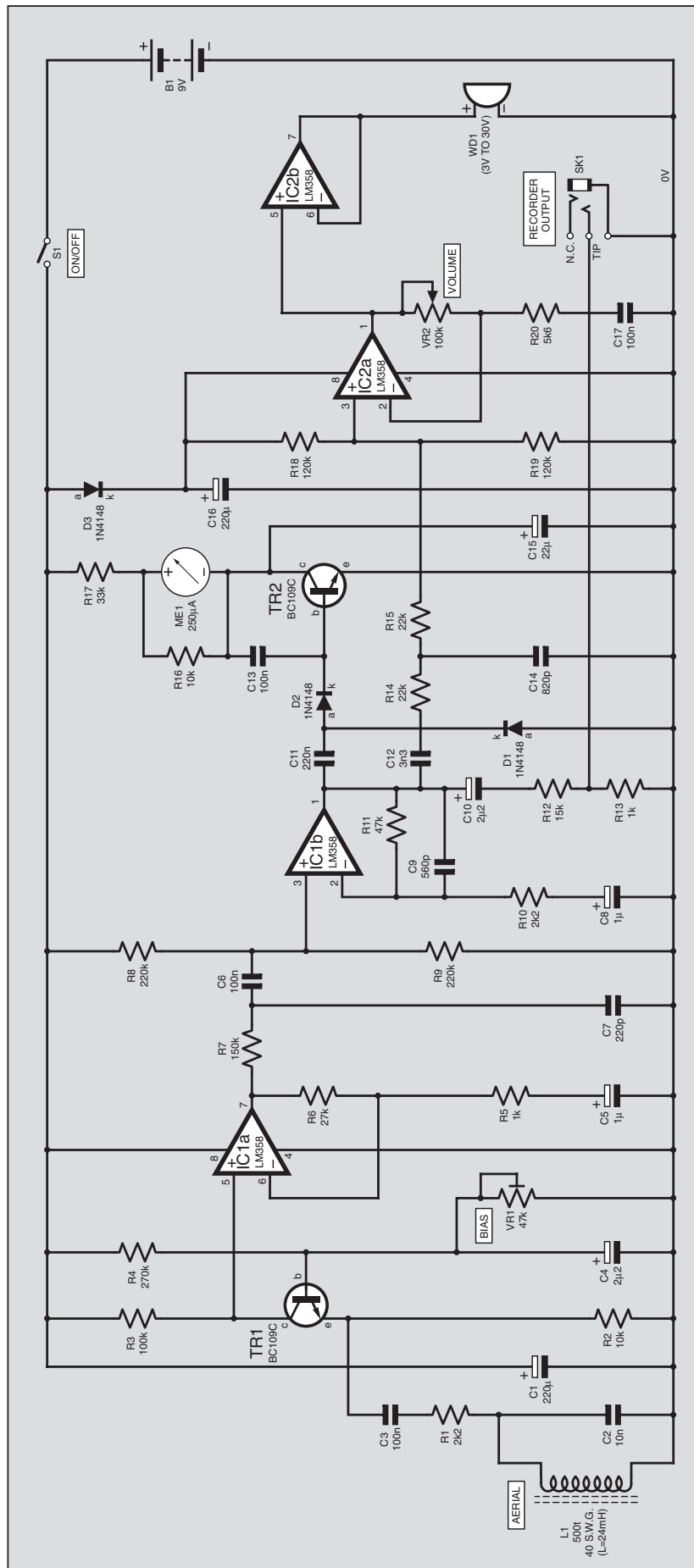


Fig. 1. Complete circuit diagram for the Atmospherics Monitor.

level, and the average activity appears between  $-11\text{dB}$  and  $-4\text{dB}$  over a range of 1000 miles, but can peak in times of storms to  $+1\text{dB}$  of short duration electrostatic pulses.

The output from IC1a is a.c. coupled to the second stage, around IC1b, where further gain of about  $\times 22$  is given, as set by resistors R10 and R11. Capacitor C9 limits the upper frequency response in order to maintain stability.

The output from IC1b is taken in three directions. The first route is to the stage around transistor TR2. The signal is rectified by diodes D1, D2 and capacitor C13, and then amplified by TR2 to drive the  $250\mu\text{A}$  meter ME1.

This signal activity meter provides weighted readings of atmospheric discharges. On quiet days the meter pointer will deflect to a quarter of its scale, but can change to half or more of full scale readings as inter-cloud activity builds up. Really frenetic activity will produce full scale deflection. On power-up the meter swings to full scale deflection to indicate good battery condition.

The output from IC1b is also a.c. coupled via capacitor C10 and

attenuated by resistors R12 and R13. This signal is suitable for feeding to the microphone input of a tape recorder.

Thirdly, the output from IC1b feeds via capacitor C12 and resistors R14 and R15 to the audio gain stage provided by IC2a. The gain is set by potentiometer VR2. The output from IC2a is buffered by unity-gain stage IC2b which drives a resonant piezo sounder having 80dB of gain.

Referring again to Fig.2, the lower graphic curve shows the response at the output of IC2b. It has similar characteristics to the upper curve, but has been given a reduced roll-off at 7.3kHz. This is primarily due to the sounder resonating at 4.6kHz, although not very sharply.

A standard loudspeaker was found to be unsuitable in this application, because the induction between the aerial and speaker would cause feedback when the volume was increased. By using a piezo sounder the output's electromagnetic field is kept exceptionally low.

In practice, the amplifier output stage's micro eddy currents are the limiting factor, so the overall gain is set such that soft sounds can just be heard above the background noise, without causing signal feedback.

Power for the circuit can be provided by a 9V PP3 battery.

Current consumption is about 2mA maximum. The supply is smoothed by capacitor C1 for the stages up to TR2. For the output stage around IC2, the supply is via diode D3, smoothed by capacitor C16. This is to minimise instability in the rest of the circuit from large electromagnetic pulses.

## CONSTRUCTION

The Atmospherics Monitor is constructed on stripboard. The component layout and track cut details are shown in Fig.3. Note that some resistors are mounted vertically. Use sockets for both i.c.s. Assemble in order of ascending component size.

The aerial ferrite rod required should be 200mm long by 10mm diameter. The use of two 100mm rods is permissible, but they

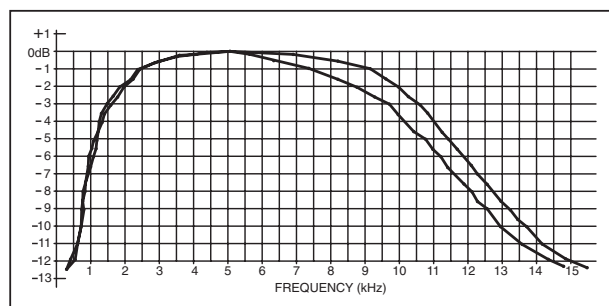


Fig.2. Monitor frequency responses.

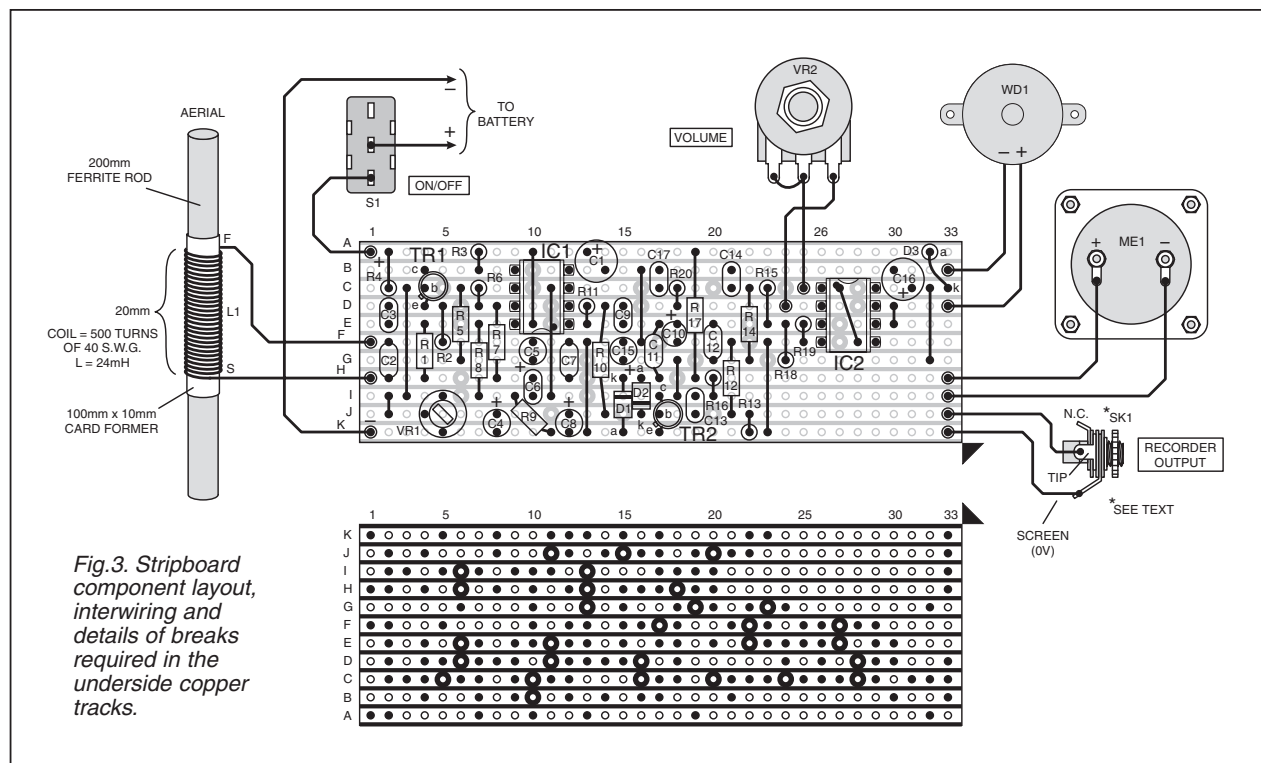


Fig.3. Stripboard component layout, interwiring and details of breaks required in the underside copper tracks.





The translucent "furniture cup" is held in position on the case by the sounder mounting lugs.

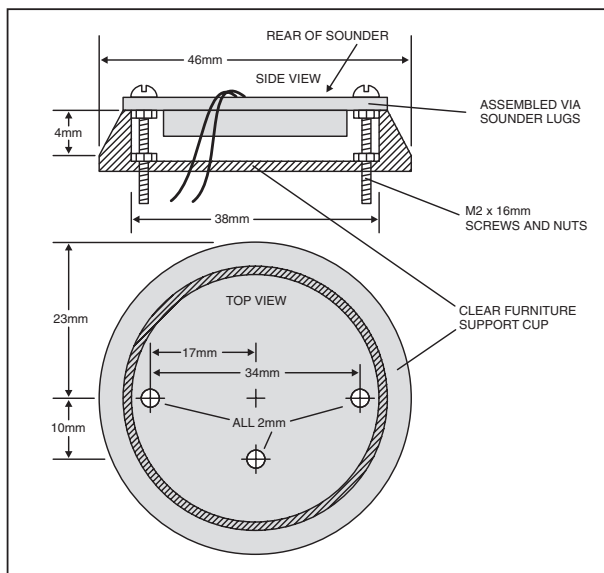


Fig.4. Suggested method of mounting the piezo sounder on the outside of the case.

must be glued end-to-end whilst held under pressure. The coil former should be 100mm in length, formed from thin cardboard into a tube that can be slid tightly over the rod to span its centre.

## COIL WINDING AND ASSEMBLY

The coil requires 500 turns of 40s.w.g. enamelled copper wire. This should be wound onto the cardboard former, within a 20mm area, back and forth. It is not necessary to have every coil turn side by side, far more important is that the finished

result has an even coil surface, by filling in gaps with turns as an ongoing process. At the last turn, label this wire as the finished over-winding (marked F in Fig.3), for negative 0V connection to the stripboard. The inductance value is roughly 24mH. Insulating tape can be used to secure the coil turns in position, or use glue.

The rod assembly needs supporting onto resilient mounts, but do not use rubber

case measuring 66mm x 38mm x 140mm, with holes drilled as appropriate.

The aerial was enclosed in a plastic plumbing pipe having an internal diameter of approximately 14mm and a total length of 225mm. The tube was cut and inserted into a plastic "T" junction which was pushed into a hole cut into the case and glued in place. The two ends of the pipe were covered by caps of the same diameter. A plastic pipe clip bolted to the case helps to provide further rigidity of the assembly.

Plastics adhesive bonded the aerial assembly attachments, although this should not be applied until after the unit has been proved to be working correctly.

## LISTENING TIMES

Atmospheric activity is primarily East to West, so the aerial rod's length should be aligned with this direction. The period between sunrise and midday tends to be quiet for atmospheric activity. However, from midday to late evening, the clouds and thunderstorms build up through heating and convection, particularly in the summer and autumn months. By sunset the atmospheric activity becomes frenetic, and the Pings, Chirps, Clicks, Hooks and Chinks are likely to be heard.

From midnight to sunrise regular Tweaks and Risers might be heard. Dawn Chorus, as its name suggests, can be heard particularly at sunrise, also other times if Aurora activity is high. Whistlers though, require active solar flare ion bursts via ducting conditions, to produce this sound.

Using the unit indoors, you are likely to encounter interference, mainly from television and computer monitors, but also house wiring to a lesser degree. However, by varying the orientation of the aerial, you can null-out very sharply the majority of unwanted hum and other numerous near-field electromagnetic activity radiated within the home.

The best results come when you are monitoring out of doors in the evening night sky. Moreover, this has its own charm, while you ponder the wonder of our world and the universe beyond the stars! □

grommets. Instead, use either foam or other soft but supporting material, to ensure the rod and coil are unable to make direct intermittent contact within the casing area.

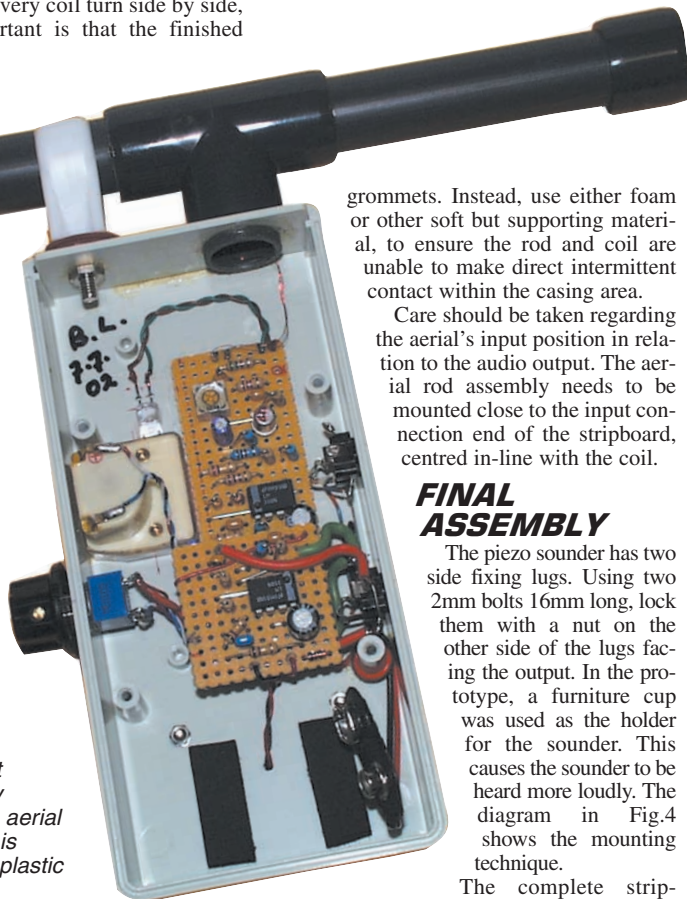
Care should be taken regarding the aerial's input position in relation to the audio output. The aerial rod assembly needs to be mounted close to the input connection end of the stripboard, centred in-line with the coil.

## FINAL ASSEMBLY

The piezo sounder has two side fixing lugs. Using two 2mm bolts 16mm long, lock them with a nut on the other side of the lugs facing the output. In the prototype, a furniture cup was used as the holder for the sounder. This causes the sounder to be heard more loudly. The diagram in Fig.4 shows the mounting technique.

The complete stripboard assembly was mounted in a plastic

General layout inside an early prototype. The aerial coil ferrite rod is housed in the plastic pipe.



## Fibreless Optics

**Optical communication works fine in fibres but its performance in free space is not bad either. Andy Emmerson elucidates.**

**M**ENTION optical communications and immediately you think of fibre. Whether it's mind-boggling capacity expansion achievements in dense wavelength-division multiplexing, unreplicated fibres spanning huge distance, or new developments in fibre-to-the-desk, they all serve to keep fibre optics constantly in mind. Marvellous as this may be, fibre is not the only way to go. Optical communication works equally well outside the confines of waveguides, as users of heliographs and smoke signals have known for two thousand years or more.

In most people's minds, though, there's a big difference between "piped" optics and signalling by light in free space. Fibre is futuristic, free space is somehow dated and potentially uncertain. Given the low cost of wired communication and the all-pervasive nature of wireless, apart from in fibres why on earth would anyone wish to send their messages on a beam of light?

Immediacy, cost, security and freedom from irksome regulation is the short answer. Lightwave transmission links can be set up at short notice over a variety of line-of-sight routes – great for broadcasters or companies needing a quick hook-up between two nearby buildings. The true cost is frequently lower than the alternative options and eavesdropping is effectively impossible in many cases. Finally, because no use is made of cables or radio frequencies, there are no costs and delays resulting from licensing problems.

This is true but it is also a simplification. Lightwave communication in free space takes many forms and these in turn have many differing applications.

### **SHORT RANGE**

Currently the highest profile in the world of optical comms must be accorded to the infra-red systems used for extremely short-range data synchronising applications. All kinds of portable computers, palmtops and electronic organisers use infra-red for data exchange, the advantages being infra-red's minimal battery drain and the fact that it does not require additional hardware or cables on the user's system.

According to the Infra-red Data Association, established in 1993 to create and maintain international standards for the hardware and software used in infra-red communication links, infra-red plays an important role in wireless data communication as it suits the use of laptop computers, wireless data communication and other digital equipment such as personal assistants, cameras, mobile telephones and pagers. The Infra-red Data Association (IrDA) 1.1 standard is a maximum data transmission size of 2,048bytes, and a maximum transmission rate of 4Mbits/s, rising to 16Mbit/s in the near future.

Companies in the USA have extended the concept to supply local area networking systems for office use, although these have only a one-metre range, which may be unsuitable in cluttered environments. Some observers argue that the Bluetooth radio-frequency systems will replace infra-red technology although this overlooks its own shortcomings of bandwidth, coexistence problems with other technologies and that fact that Bluetooth has been pre-sold to such an extent that it will have a tough job living up to user expectations. The most likely scenario is peaceful coexistence.

### **UP, UP AND AWAY**

Outdoors in the wild blue yonder optical communication is already established as a powerful technology that is the equal of both microwave radio and fibre-optic cables.

Optical systems work in the infra-red or near infra-red region of light and the easiest way to visualise how they work is to imagine two points interconnected with fibre optic cable and then remove the cable. Optical free space laser communications systems are truly wireless (wire-free if you prefer) connections communicating through the atmosphere by light wave transmission, the beam being transmitted through open space rather than glass fibre.

The infra-red carrier used for transmitting the signal is generated either by a high-power I.e.d. or a laser diode. Two parallel beams are used, one for transmission and one for reception, taking a standard data, voice or video signal, converting it to a digital format and transmitting it through free space. Today's modern laser systems provide network connectivity at speeds of 155Mbit/s and will soon have the capacity to achieve 622Mbit/s and beyond with total reliability.

### **FULLY PROVEN**

It is a fully proven technology too, with tens of thousands of installations worldwide. Lack of industry awareness is the chief problem but even this is changing,

states Richard Redgrave, marketing director of British company PAV Data Systems Ltd. PAV is recognised as a leader in "last mile" networking, its products being exported worldwide. Its Windermere plant produces broadband optical wireless access systems with data rate capacities operating from T1 (1.5Mbit/s) through to SDI (270Mbit/s) at distances up to six kilometres.

The biggest drawbacks are severe weather conditions that interrupt the beam – extremely dense fog or sunlight shining directly into the receiver diode. Both of these cases are fairly rare and research shows that infra-red technology operates at an operational availability rate of between 99.1 and 99.9 per cent, equalling microwave radio's performance.

Birds are the other hazard for free-space light beam communications; what happens if a bird flies across the path? In fact birds can see the infra-red region of the spectrum and will usually avoid the beam. If a bird (or any other object) should pass through the beam, no harm will be done. The transmission will of course be interrupted momentarily, although Ethernet and Token Ring will re-transmit the data as per protocol.

### **BRIGHT RED FUTURE**

Infra-red technology, claims the IrDA, is as secure as cable applications and can be more reliable than wired technology as it obviates wear and tear on the connector hardware. In the future, it is forecast that this technology will be implemented in copiers, fax machines, overhead projectors, bank ATMs, credit cards, game consoles and headsets. All of these have local applications and it is really here where this technology is best suited, owing to the inherent difficulties in its technological process for interconnecting over distances.

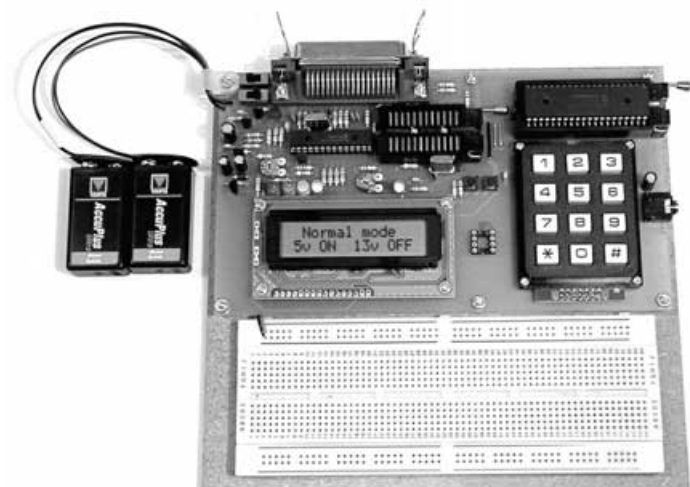
Outdoors too, its use is bound to grow as communications companies, broadcasters and end users discover how crowded the radio spectrum has become. Once infra-red's image issue has been overcome and its profile raised, the medium will truly have a bright, if invisible, future.

### **Haven't we heard this before . . . ?**

Cast your mind back, if you can, to the Summer of Love (perhaps there were several so let's call it 1968). Londoners devastated by the loss of Radio Caroline and gasping for an antidote to the all-too-restrained Radio 1 of the BBC were promised an entirely new station called Radio Love.

Radical in more ways than one, it planned to beat the state monopoly over the airwaves by broadcasting on optical frequencies beaming down on London from the top of Centre Point. Listeners would have their transistor sets converted with a photoelectric cell and could tune into their choice of music. That was the theory; the reality never came to pass. You probably think it's an April spoof, but it's true!

# Learn About Microcontrollers



## PIC Training & Development System

The best place to start learning about microcontrollers is the PIC16F84. This is easy to understand and very popular with construction projects. Then continue on using the more sophisticated PIC16F877 family.

The heart of our system is a real book which lies open on your desk while you use your computer to type in the programme and control the hardware. Start with four very simple programmes. Run the simulator to see how they work. Test them with real hardware. Follow on with a little theory....

Our complete PIC training and development system consists of our universal mid range PIC programmer, a 306 page book covering the PIC16F84, a 262 page book introducing the PIC16F877 family, and a suite of programmes to run on a PC. The module is an advanced design using a 28 pin PIC16F872 to handle the timing, programming and voltage switching requirements. The module has two ZIF sockets and an 8 pin socket which between them allow most mid range 8, 18, 28 and 40 pin PICs to be programmed. The plugboard is wired with a 5 volt supply. The software is an integrated system comprising a text editor, assembler disassembler, simulator and programming software. The programming is performed at normal 5 volts and then verified with plus and minus 10% applied to ensure that the device is programmed with a good margin and not poised on the edge of failure. Requires two PP3 batteries which are not supplied.

Universal mid range PIC programmer module  
 + Book Experimenting with PIC Microcontrollers  
 + Book Experimenting with the PIC16F877 (2nd edition)  
 + Universal mid range PIC software suite  
 .....+ PIC16F84 and PIC16F872 test PICs. . . . . £157.41  
 UK Postage and insurance. . . . . £ 7.50  
 (Europe postage & Insurance. . £13.00. Rest of world. . £24.00)

## Experimenting with PIC Microcontrollers

This book introduces the PIC16F84 and PIC16C711, and is the easy way to get started for anyone who is new to PIC programming. We begin with four simple experiments, the first of which is explained over ten and a half pages assuming no starting knowledge except the ability to operate a PC. Then having gained some practical experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Für Elise*. Finally there are two projects to work through, using the PIC16F84 to create a sinewave generator and investigating the power taken by domestic appliances. In the space of 24 experiments, two projects and 56 exercises the book works through from absolute beginner to experienced engineer level.

## Ordering Information

Telephone with Visa, Mastercard or Switch, or send cheque/PO for immediate despatch. All prices include VAT if applicable. Postage must be added to all orders. UK postage £2.50 per book, £1.00 per kit, maximum £7.50. Europe postage £3.50 per book, £1.50 per kit. Rest of World £6.50 per book, 2.50 per kit.

Web site:- [www.brunningsoftware.co.uk](http://www.brunningsoftware.co.uk)

Mail order address:

**Brunning Software** 138 The Street, Little Clacton, Clacton-on-sea,  
 Essex, CO16 9LS. Tel 01255 862308

## NEW 32 bit PC Assembler

*Experimenting with PC Computers* with its kit is the easiest way ever to learn assembly language programming. If you have enough intelligence to understand the English language and you can operate a PC computer then you have all the necessary background knowledge. Flashing LEDs, digital to analogue converters, simple oscilloscope, charging curves, temperature graphs and audio digitising. Kit now supplied with our 32 bit assembler with 84 page supplement detailing the new features and including 7 experiments PC to PIC communication. Flashing LEDs, writing to LCD and two way data using 3 wires from PC's parallel port to PIC16F84.

Book *Experimenting with PCs* ..... £21.50  
 Kit 1a 'made up' with software ..... £52.00  
 Kit 1u 'unmade' with software ..... £45.00

## C & C++ for the PC

*Experimenting with C & C++ Programmes* teaches us to programme by using C to drive the simple hardware circuits built using the materials supplied in the kit. The circuits build up to a storage oscilloscope using relatively simple C techniques to construct a programme that is by no means simple. When approached in this way C is only marginally more difficult than BASIC and infinitely more powerful. C programmers are always in demand. Ideal for absolute beginners and experienced programmers.

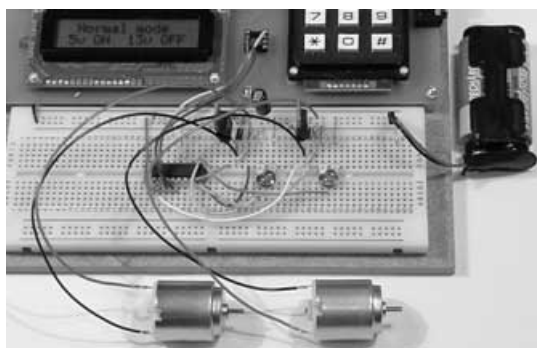
Book *Experimenting with C & C++* ..... £24.99  
 Kit CP2a 'made up' with software ..... £32.51  
 Kit CP2u 'unmade' with software ..... £26.51  
 Kit CP2t 'top up' with software ..... £12.99

## The Kits

The assembler and C & C++ kits contain the prototyping board, lead assemblies, components and programming software to do all the experiments. The 'made up' kits are supplied ready to start. The 'top up' kit is for readers who have already purchased kit 1a or 1u. The kits do not include the book.

## Hardware required

All systems in this advertisement assume you have a PC (386 or better) and a printer lead. The experiments require no soldering.



## Experimenting with the PIC16F877

The second PIC book starts with the simplest of experiments to give us a basic understanding of the PIC16F877 family. Then we look at the 16 bit timer, efficient storage and display of text messages, simple frequency counter, use a keypad for numbers, letters and security codes, and examine the 10 bit A/D converter.

The 2nd edition has two new chapters. The PIC16F627 is introduced as a low cost PIC16F84. We use the PIC16F627 as a step up switching regulator, and to control the speed of a DC motor with maximum torque still available. Then we study how to use a PIC to switch mains power using an optoisolated triac driving a high current triac.



## LEGALISED DVD COPYING?

Could a new product allow you to copy commercial DVDs without breaking the copyright law? asks Barry Fox

A COURT in California must now decide whether PC owners can use an ingenious new software program that achieves what is apparently impossible. It makes perfect digital copies of DVD movie disks, without defeating their electronic copy-protection. The software, called DVDXcopy, has been developed by US company 321 Studios and is now on sale over the Internet for \$100.

321 believes Xcopy steers clear of laws, including the 1998 Digital Millennium Copyright Act, which prohibit circumvention of copy protection, and Xcopy should be legal because it lets people make personal "back up" copies of DVDs they have bought.

### Key Concept

The movie on a DVD is stored as digital code, compressed with the MPEG system. The code is encrypted with the Content Scrambling System, and unscrambling is only possible on an authorised DVD player or computer DVD ROM drive which contains CSS de-encryption keys secured in its control chips. The keys in the player mate with more keys buried in hidden parts of the DVD disk. If a computer is used to make a bit-for-bit copy of a DVD, the copy will not play on a DVD player because some of the vital keys do not copy along with the movie.

As extra security the analogue TV signal which comes out of the player is processed with the Macrovision analogue copy-protection system.

Unauthorised software called DeCSS can defeat the CSS digital protection, and black-box "signal cleaners" can be bought to defeat Macrovision. In most countries this is illegal. In the US the penalty can be five years in gaol and a \$0.25m fine. But Xcopy does not defeat DVD's protection systems. Instead it shoehorns between them by copying the digital MPEG code just after it has been legitimately unscrambled from the DVD by an authorised player and just before the unscrambled code is converted into a protected analogue TV signal.

### There's A Cache To It

Xcopy sends the unscrambled MPEG code to a temporary "cache" file on the PC's hard disk. Then it copies the cached code onto a blank DVD, and deletes the temporary store. The copy disk plays perfectly.

Hands-on tests support 321's claim that "It couldn't be easier! Install on

Computer; insert Blank DVD Disk; press COPY NOW to Backup DVD". It is even possible to copy the copy DVD back to a computer hard disk, and from there to another blank DVD. It took only around an hour to copy a two hour movie. DVD Audio disks can also be copied; the Advanced Resolution tracks are ignored while Xcopy transfers the Dolby Digital and DTS replicas.

"Every backup copy you make is *exactly* like the original. Nothing is compressed or left off the disk," claims 321.

So now, says 321, people can take their favourite movies on the plane, in the car, or wherever they go. If the copy disk gets lost, stolen, or scratched, the original is still safe at home.

### Muddy Waters?

Earlier this year 321 tested the legal waters with a system which spread a

movie over several blank CDs. 321 then sued the nine major Hollywood studios, including Disney, Universal and Warner, when they complained. Now 321 is asking the District Court in San Francisco to rule that selling Xcopy software to make backup copies of DVDs onto blank DVDs does not violate the DCMA or any other US law. The studios have now counter-sued.

321 is also encouraging people to petition the US Congress for correction of "an unintended consequence of the DCMA".

The Motion Picture Association of America says it is staying silent until the case comes to court but the MPAA claims that \$3bn is lost on piracy each year and is already finding "burner" factories which illegally copy movies to blank DVDs discs. The MPAA says it "looks forward" to the European Parliament passing tough laws like the DCMA.

## CHATPEN

THE Feb '03 issue of the RSGB Members' magazine, *RadCom*, contains an article by Steve White G3ZVW in which he publicises a remarkable writing aid.

In brief, Steve highlights the so-called Digital Ink Pen produced by Anoto. It works like any other ball point pen, but it contains an interesting feature – the ability to store and wirelessly transmit what you have written.

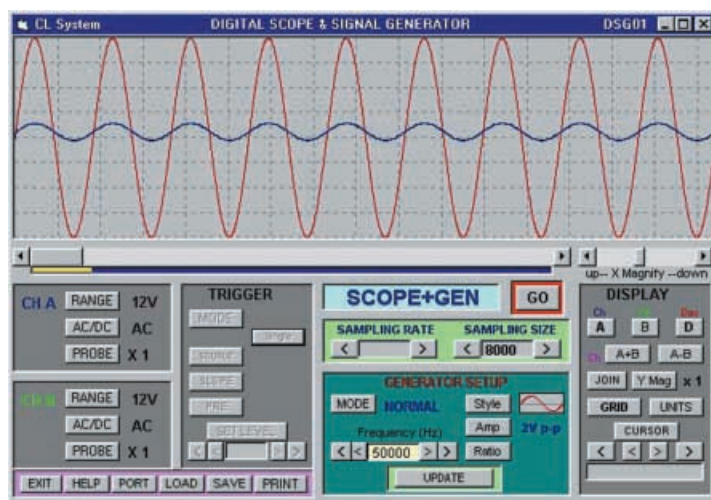
The pen contains a tiny camera that scans your writing at 70

frames a second. It uses a grid to recognise when and where the tip is in contact with the paper and has a graphics capability of 86dpi. The captured data can be retrieved and transmitted, using Bluetooth, to a suitably equipped PC or cellphone, with a range of about 30ft.

Anoto's technology is used in the Sony Ericsson *ChatPen*, and Logitech produce a similar model. Anoto's web site is at [www.anoto.com](http://www.anoto.com). Also do a search via [www.google.com](http://www.google.com), on "Sony Ericsson Chatpen" – lots of entries to browse. The RSGB's web site is at [www.rsgb.org](http://www.rsgb.org).



## PC DIGITAL SCOPE



CL SYSTEM has announced a compact and smart module that turns your PC or laptop into a fully-fledged digital oscilloscope and signal generator. Ideal for capturing once-occurring events, the DSG samples at up to 30MHz, with a buffer size of 32K bytes.

It will generate sine, saw and triangular signals in normal and sweep formats, and is programmable to generate other waveforms. It supports data input from Microsoft Excel. With both scope and signal generator functions, the DSG becomes a versatile component tester, plugging into a PC printer port.

The system supports Win 95/98/ME/NT/2000/XT. Minimum spec is a 486 PC with 8MB of memory, EPP or ECP printer port, CD-ROM drive and 20MB disk space. Price starts at £139.

For more information contact CL System, Dept EPE, 35 Charterhouse Avenue, Wembley, Middx HA0 3DD. Tel: 07986 860815. Email: clang@clsystem.co.uk. Web: www.clsystem.co.uk.

## MOTOROLA MICROS

READERS can perhaps be forgiven if they think that PICs are the only microcontrollers available. Whilst *EPE* has standardised on PICs, in fact there are numerous other microcontrollers manufactured by organisations other than Microchip.

Motorola, for example, have recently introduced a microcontroller that could well find favour with those who have been in electronics for some time and who remember with affection such microprocessors as the 6502 and the language structure used in it and others of similar type.

Motorola's new microcontroller family of 68HC908QT/QY devices could be of interest to such readers. One of the main technical features of the QT/QY family is the CPU08 core, which is code compatible with the industry standard HC05 micro. This was one of the leading controllers of the 90's, selling more than five billion units.

The 68HC908 devices, known also as the Nitron family of 8-bit flash MCUs, feature in-circuit reprogrammable memory of 1.5K to 4K bytes, and a number of on-chip peripherals, including a 2-channel 16-bit timer system with selectable capture, compare and PWM, and 4-channel 8-bit ADC.

An evaluation board is inexpensively available for these devices, featuring a battery powered 68HC908QT4, i.e.d.s, potentiometer, pushbutton switch, access to all I/O, software demo and application code. The board is available from Motorola's distributors worldwide at the suggested retail price of US\$25.

Motorola offers 68HC08 web-based training, and has a large library of applications and complete reference designs. A large base of hardware and software development tools are available and the family is also supported by a free Metrowerks CodeWarrior Development Studio Special Edition.

For more information browse [www.motorola.com/mcu](http://www.motorola.com/mcu).

## SELF-DESTRUCT CDS

By Barry Fox

AFTER six years of legal manoeuvring, SpectraDisc of Providence, Rhode Island has won a master patent (US 6 343 063) that covers all its key ideas for making CDs, DVDs and computer ROM disks that self-destruct after a few minutes, days or weeks of use. The disk is doped with hygroscopic salts such as magnesium chloride and the surface covered with a peel-off barrier, like a record label.

When the barrier is removed to bare the disk for play, the salts start to pick up moisture from the air. The corrosive mix then begins to eat away the aluminium layer of the disk that reflects the laser light in the player. The disk can also contain an indigo dye which darkens as it absorbs light from the player's laser. So the disk plays for a while and then stops. Balancing the mix of salts and dyes controls the permissible play times.

## KEENE'S CAT

KEENE Electronics was established in 1988 and has since evolved around the design, manufacture and distribution of audio and video accessories. Keene say that they sell interesting, useful, and sometimes hard to find bits and pieces designed to make your life easier, whether you are a camcorder specialist, home cinema fan or general gadget addict!

If you are any of these, Keene's latest catalogue, containing over a hundred A4 full-colour pages, is a *must* for you. There is too much to categorise, but it seems likely that you will find what you are looking for, as well as being helped to make more informed decisions about future purchases.

For more information contact Keene Electronics, Dept EPE, Unit 9, Old Hall Mills Business Park, Little Eaton, Derbys DE21 5DN. Tel: 0870 990 9000.

Fax: 01332 830551.

Email: [sales@keene.co.uk](mailto:sales@keene.co.uk).

Web: [www.keene.co.uk](http://www.keene.co.uk).

## MOTOR CROUZING

CROUZET manufacture a wide range of d.c. motors and associated gearboxes. They have recently appointed the Camis Group as their UK specialist distributor.

Martin Hyde, Crouzet's Marketing Manager, comments that customers will be able to have their d.c. motors and gearboxes configured locally in the UK. "The

Camis offer includes supplying adapted products, control systems and even complete products and assemblies if required", he says.

For more information contact Camis Electronics Ltd., Dept EPE, Platts Road, Stourbridge DY8 4YR. Tel: 01384 441402. Web: [www.camis.demon.co.uk](http://www.camis.demon.co.uk).

## TECHNOLOGY TRAINING

BOURNEMOUTH University has sent us a flyer promoting their School of Design, Engineering and Computing. This is said to maintain excellent links with industry and commerce through a thriving programme of research, consultancy, technology transfer and professional training. Bournemouth University continues to have one of the highest employment rates for new graduates, of all UK universities.

Short courses also form an important part of their Continuing Professional Development programme, usually having a duration of one to five days. They typically include hands-on laboratory sessions to enable you to practise new skills under expert guidance.

Contact details: Technology Transfer Centre, Bournemouth University, Talbot Campus, Fern Barrow, Poole, Dorset BH12 5BB. Tel: 01202 595506.

Fax: 01202 595559.

Email: [ttc@bournemouth.ac.uk](mailto:ttc@bournemouth.ac.uk).

Web: [www.dec.bournemouth.ac.uk](http://www.dec.bournemouth.ac.uk).

# INTELLIGENT GARDEN LIGHTS CONTROLLER

MAX HORSEY



*An easy-build lights controller that knows when it's time to switch off*

Since the most convenient way of programming the device is by means of the PICAXE system (see Nov '02), resistors R1 and R2 are connected to the three-pin input connector TB1 to enable direct

**T**HIS project was developed for use with garden lights or any lighting system, including Christmas lights, which need to illuminate at dusk, but turn off around midnight.

Many existing lights are controlled by timers, but these have to be continually reset during Autumn and Spring as the period of daylight changes. Often lights are controlled by sensors such as l.d.r.s, in which case the light stays on all night, which is not ideal.

A system which turns on at dusk, but switches off at around midnight would require a light sensor, and a real time clock, which in turn requires a means of setting the time, and occasional re-setting. All very inconvenient!

## HOW IT WORKS

Many garden lights are supplied with a power adaptor, and so the circuit was designed to operate on the 12V a.c. or d.c. supply that was already provided with the lighting set. For example, the garden lights in question were supplied with a power adaptor rated at 12V a.c. Hence the circuit first converts the supply to d.c. before regulating it down to 5V. The output to the garden lights is via a p.c.b. mounted relay, with mains rated contacts.

The block diagram of the system is shown in Fig 1. The light sensor monitors the level of light, and is connected to an analogue input at the PIC microcontroller.

The first time the system is used, the Set button is pressed during dusk, at the point at which the lights are required to come on. This setting is retained by the PIC even during power loss. It can be reset if required by pressing the Set button as described later.

The PIC indicates day or night, and whether the garden lights are switched on by means of three coloured l.e.d.s. Another output controls the relay which in turn switches the a.c. (or d.c.) supply to the garden lights. Any 12V power supply may be

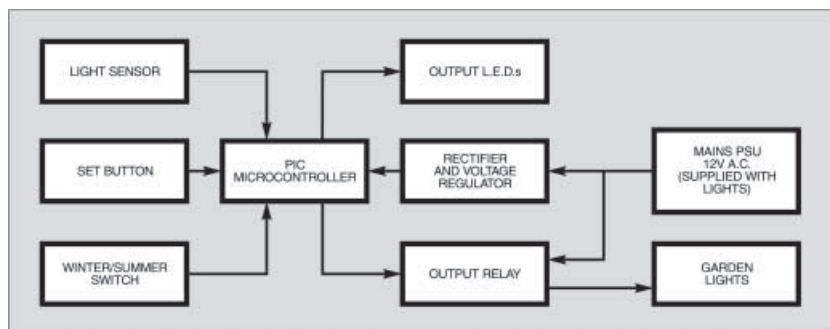


Fig.1. Block diagram for the Intelligent Garden Lights Controller.

employed, and since the current required by the circuit is very small, it is ideally powered by the supply that is intended for the garden lights.

## CIRCUIT DESCRIPTION

The full circuit diagram for the Intelligent Garden Lights Controller is shown in Fig.2. At the heart of the circuit is the microcontroller i.c., a PIC16F627.

programming from the serial port of a computer. Note that this can only be done if a pre-configured i.c. (known as PICAXE-18) is obtained from Revolution Education – full details later.

## MORE ON PICAXE

A PICAXE-18 i.c. is a PIC16F627 device into which special software has been added to enable serial programming





via a lead direct from a PC. In other words, no programming hardware board is required, and the PIC is programmed "in-circuit". This, it is claimed, makes programming changes and experiments easy.

One of the disadvantages is that the PICAXE-18 is less widely available than a standard PIC16F627, and programs have to be fairly short. The advantage is that having bought the PICAXE-18 and serial lead all the required software is available free by downloading, or for a nominal charge on floppy disk. The programming system is in a form of BASIC, and is remarkably straightforward. Of course, you

## FEATURES . . .

- Switches on automatically at dusk
- Times the length of the night until dawn, so that on subsequent nights the output is switched off halfway through the night (i.e. around midnight)
- Initial setting achieved by pressing a pushswitch at the chosen point during dusk. This value is retained in memory for subsequent nights
- Dusk turn-on setting and length-of-night settings are stored in EEPROM in case of power loss
- Summer/Winter selector switch can be fitted if required

Set switch S2 at the required moment during dusk. The voltage at RA0/AN0 is noted by the PIC, and this value is remembered for subsequent automatic switch-on. Capacitor C1 removes any electrical noise that could be a problem if l.d.r. R5 is connected via long leads.

## SUMMER/WINTER

Pin RA7 monitors the Summer/Winter switch S3. If this switch is omitted, then the default is "summer-time", i.e. the system will switch off at midnight during summer, and at 11pm in winter.

If S3 is fitted and closed, the circuit is set to "winter-time"

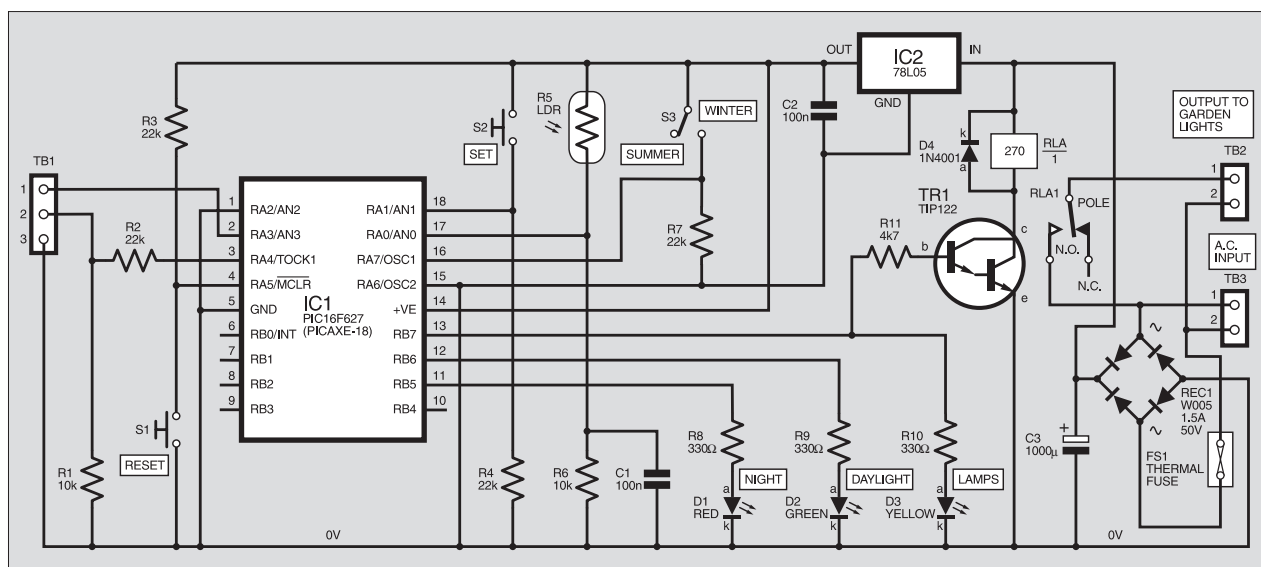


Fig.2. Complete circuit diagram for the Intelligent Garden Lights Controller.

can download the program for this project from the EPE website.

For those wishing to program a PIC16F627 in the conventional way, a HEX version of the program is provided. Note that the PIC16F627 is similar to the popular PIC16F84A, and can be re-programmed many times.

However, it has an in-built oscillator, and is cheaper than the PIC16F84A. If serial programming is not required, connector TB1 can be omitted, but resistors R1 and R2 are best included to tie the serial input to 0V.

Pin 4 of IC1 is "master clear" (MCLR). The Reset switch S1 may be omitted since the i.c. is reset every time it is powered up.

However, it may be required on the odd occasion with PICAXE-18 if latch-up occurs during programming. Hence two terminal pins may be employed rather than a switch so that they can be bridged with a screwdriver blade on the very rare occasion that reset is required. Note that resistor R3 is essential whether or not the reset function is required.

## INPUT PINS

Pin 5 is the negative (0V) supply pin, and all unused Port A analogue inputs are tied to the 0V line. The Set switch S2 is connected to the input at RA1/AN1. Being a "normally-open" pushswitch,

resistor R4 holds this pin at 0V. When S2 is pressed the pin switches to positive (5V). This is interpreted by the PIC as logic 1.

Pin RA0/AN0 is employed as the light level sensing analogue input. It monitors the voltage at the junction of R5, the light dependent resistor (l.d.r.), and resistor R6. This voltage will rise as the amount of light falling on the l.d.r. increases.

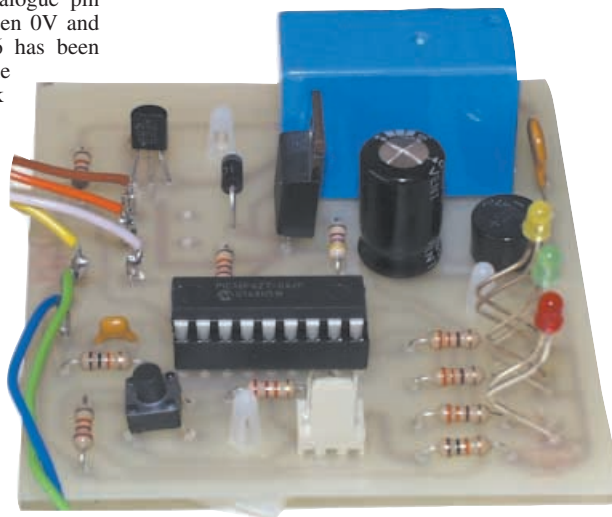
In this arrangement, the analogue pin can only detect voltages between 0V and about 3V, so the value of R6 has been chosen to provide an acceptable range during the period of dusk and dawn. A variable resistor (potentiometer) would often be chosen in place of R6, but this complicates the setting-up procedure, and a value of 10k should provide the range required.

Note that the user still chooses the exact moment of "switch-on" by pressing the

(GMT) and will switch off at midnight during winter, but 1 a.m. in summer. The circuit can be permanently set to winter-time by fitting a wire link in place of S3. If S3 is included, then the circuit can be made to switch off at midnight all year round. Resistor R7 ensures that RA7 is never left "floating".

If the standard (i.e. non PICAXE-18) PIC16F627 is employed, then RA3/AN3

*Finished circuit board. Note how the l.e.d. leads have been bent to align with the small holes in the case lid.*



and RA4/T0CK1 should be connected to 0V since they are not required. Resistors R1 and R2 will maintain RA4 at 0V, the hex software configures RA3 as an input pin, so it may be tied to 0V by fitting a wire link to join pin 1 to pin 3 of connector TB1.

## OUTPUT PINS

The PIC (IC1) can supply more than enough current to light an l.e.d. quite brightly. So, outputs RB5, RB6 and RB7 are used to supply the three l.e.d.s, D1 (red), D2 (green), D3 (yellow), which indicate night-time, daytime and "lights on" respectively. Each l.e.d. is supplied via current limiting resistors (R8, R9 and R10).

Pin RB7 also drives the Darlington transistor TR1 via base current limiting resistor R11. The transistor in turn switches on the relay, note that the 5V signal from the PIC is used to switch on the 12V d.c. supply for the relay coil. The transistor acts as an interface between the low-current 12V d.c. supply and the high-current 12V a.c. supply required for the lights. Diode D4 removes the back e.m.f. produced by the relay coil when it switches off.

Note that unused Port B pins should be left open-circuit i.e. not connected. The software configures all of port B (i.e. pins RB0 to RB1) as output pins.

## POWER SUPPLY

The 12V a.c. supply (from the garden lights PSU) is applied via terminal block TB3. The supply is rectified into d.c. by means of bridge rectifier REC1. Note that if d.c. is applied to TB3 the circuit will work equally well, and the polarity of the d.c. is irrelevant. Capacitor C3 ensures that the ripple present on the rectified d.c. supply is smoothed.

Regulator IC2 provides a steady 5V supply for the PIC, and capacitor C2 removes any spikes present.

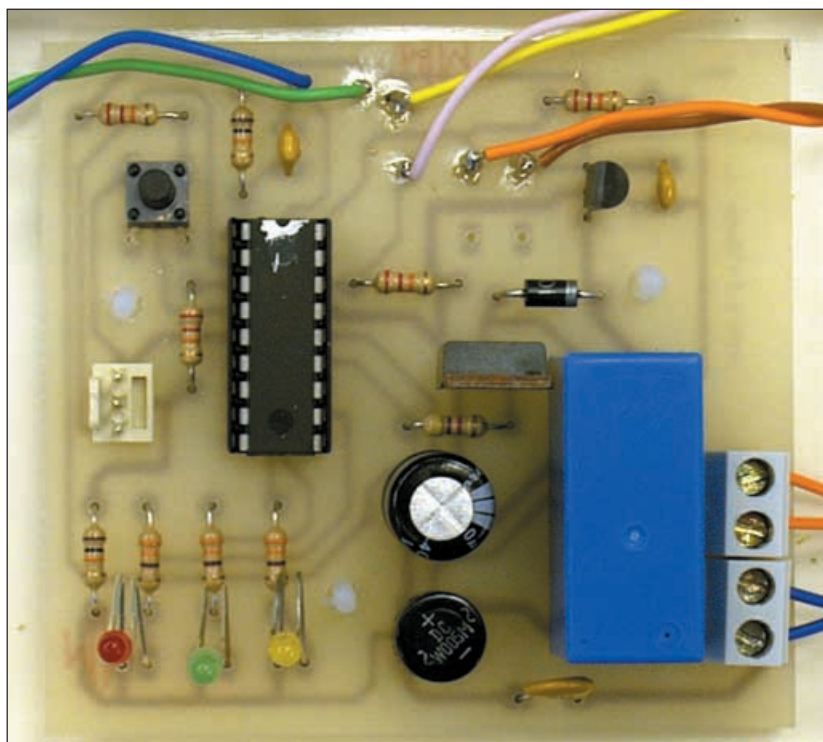
The power supply provided with the garden lights is capable of supplying a considerable current, and so the circuit is protected by means of a thermal fuse FS1. This fits into the circuit like a small capacitor and will protect the 12V d.c. section against short-circuits. The regulator IC2 limits the 5V supply to a maximum of about 100mA.

No protection is provided for the 12V a.c. supply to the lamps since this should be built into the power unit supplied. The suggested relay is capable of handling much more current than the maximum that can be supplied by a typical power unit, but if in doubt, an additional fuse can be fitted in series with the a.c. supply to the p.c.b. i.e. in series with pin 1 of terminal block TB3.

## CONSTRUCTION

Construction of the Lights Controller is based on a small (73mm x 68mm) single-sided printed circuit board (p.c.b.). The topside component layout and full-size underside copper track master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 389.

Begin construction by examining the p.c.b. to ensure that the holes for the relay and terminal blocks TB2 and TB3 are large



Components mounted on the completed printed circuit board.

enough. Also check that the three mounting holes, shown as square pads without any tracks will take the p.c.b. self-adhesive mounts.

However, do not yet fit any of these items, as it is easier to begin with the i.c. socket. Fit and solder this with its notch as shown in Fig 3. Next fit the smallest parts such as resistors and small capacitors C1 and C2.

Diode D4 must be fitted the correct way round, with its silver band as shown, as must the bridge rectifier REC1 whose positive lead is longer than the others. Capacitor C3 must be fitted with the positive (longer) lead also as shown.

Next fit the regulator i.c. IC2, with its flat side towards switch S2, and fit transistor TR1 with its metal tab nearer resistor R11. The 3-pin connector TB1 is optional,

## COMPONENTS

Approx. Cost  
Guidance Only

**£20**

excl. case & serial lead

### Resistors

R1, R6 10k (2 off)

R2, R3, 22k (4 off)

R4, R7 miniature

R5 light

dependent resistor

(l.d.r.)

R8, R9, 330Ω (3 off)

R10 4k7

R11 All 0-5W 5% carbon film, except R5

### Capacitors

C1, C2 100n disc ceramic (2 off)

C3 1000μ radial elect. 16V

### Semiconductors

D1 3mm red l.e.d.

D2 3mm green l.e.d.

D3 3mm yellow l.e.d.

D4 1N4001 50V 1A rect.

diode

TR1 TIP122 or TIP121 npn

Darlington transistor

IC1 PIC16F627 or

PICAXE-18

preprogrammed

microcontroller

(see text)

See  
SHOP  
TALK  
page

IC2

78L05 5V 100mA

voltage regulator

REC1

W005 1-5A 50V bridge

rectifier

### Miscellaneous

RLA

12V 270Ω coil, p.c.b.

mounting relay,

contacts rated 10A

240V a.c. or more

S1

p.c.b. mounting switch,

push-to-make

(optional – see text)

S2

pushbutton, low profile

switch (push-to-make)

S3

s.p.s.t toggle switch

TB1

3-pin serial connector

(shrouded 3-pin

header)

TB2, TB3

2-way screw terminal

block, p.c.b. mounting

(2 off)

FS1

0-5A thermal fuse (see text)

Printed circuit board available from the *EPE PCB Service*, code 389; plastic case, size 142mm x 81mm x 30mm approx.; 18-pin d.i.l. socket; serial download lead for PICAXE-18 (see text); connecting wire; solder pins; solder etc.



and required if the PIC is a PICAXE-18 type, and programmed directly from your computer. If TB1 is required, ensure it is fitted with its locating "tongue" towards the outer edge of the p.c.b.

The l.e.d.s D1, D2 and D3 may be mounted directly on the p.c.b. Ensure that they are fitted the correct way round, and allow them to stand well proud of the board. It will then be possible to fix the p.c.b. into the case with the l.e.d.s showing through three holes drilled in the top.

If the l.e.d. wires are bent a little, they may be positioned more easily, and fine-tuned to be at the correct height. Any colour scheme can be used, but in the prototype D1 was Red, D2 Green and D3 Yellow.

## ALL SWITCHED ON

Switches S1 and S2 can be p.c.b. mounting types if desired, although as explained earlier, S1 is hardly ever needed, and a pair of terminal pins will suffice in the unlikely event that the circuit requires a reset. The terminal pins must be fitted on the pads nearest to resistor R3, the other pads are simply to locate S1.

The prototype employed a low-cost p.c.b. switch for S1, as shown in Fig.4 and the photographs. S2 is the Set switch, and is likely to be required on the casing. Hence a pair of wires should be fitted to the pads nearest the outside edge of the p.c.b.

Switch S3 is optional and is designed to select between Summer-time and Winter-time. If S3 is omitted the system defaults

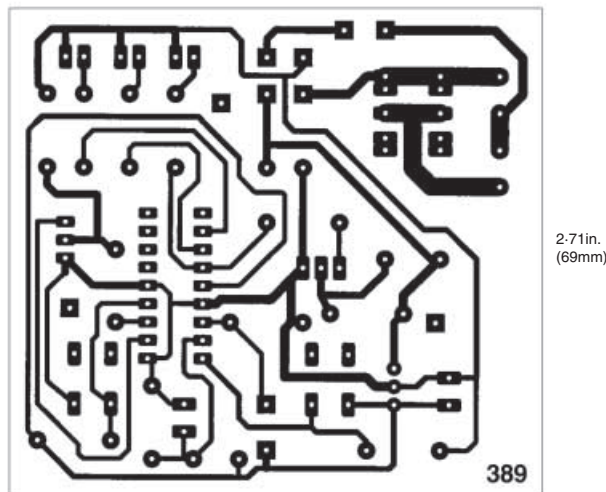
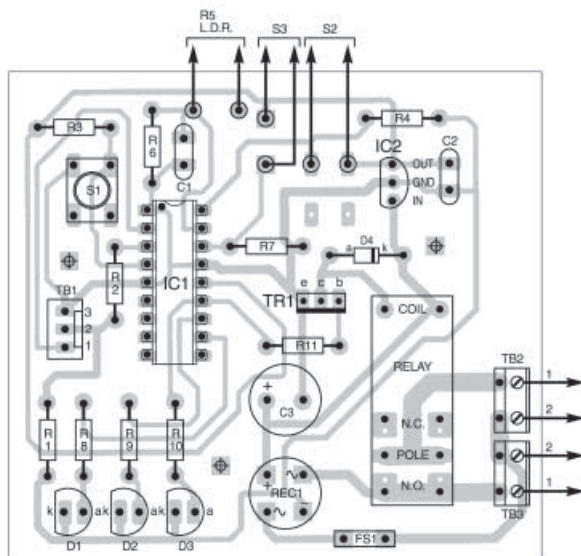


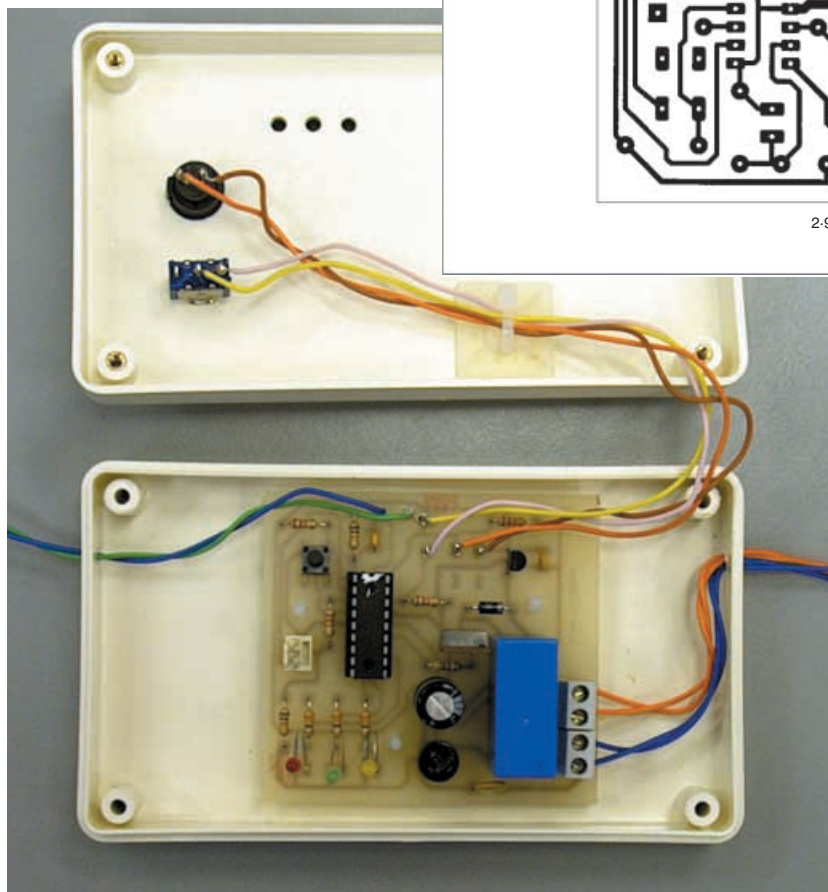
Fig.3. Lights Controller printed circuit board component layout and full-size copper track master.

to summer-time. This will cause the system to switch off the lights at 1 a.m. during the summer and at midnight during the winter.

Alternatively, a wire link in place of S3 will cause the system to switch off the lights at midnight during the summer, and 11 p.m. in winter. If S3 is included you will be able to set the system to switch off the lights at midnight all year round.

Wires should also be fitted for the l.d.r. (R5). The thermal fuse FS1 can be fitted either way round, followed by the relay. Some care must be taken to make all the relay pins find their correct holes. There are two types of p.c.b. mounting relay in common use, and the p.c.b. has been designed to accommodate either type. Hence the extra four holes which are not required.

Now fit the p.c.b. mounting terminal blocks TB2 and TB3, ensuring that the



Completed unit showing the p.c.b. mounted in the case base and the three l.e.d. locating holes in the lid.



holes for the wires are facing the outside edge of the p.c.b. Finally insert the programmed PIC into its socket, taking static precautions and ensuring it is seated the correct way round, with its notch (or dot) towards resistor R6.

## CASING UP

The p.c.b. may be housed in a slim white case measuring 140mm × 80mm × 30 mm, as shown in Fig 4. Drill holes for the three l.e.d.s, noting that if the holes are suitably aligned, the l.e.d.s may remain housed on the p.c.b. as shown in the photographs. Also drill a hole for pushswitch S2, and optional Summer/Winter switch S3. Note that S1 is not required once the PIC has been programmed and so no provision need be made.

Drill a hole for the power supply cable, and the cable connecting the garden lights, and a hole for the wire linking the l.d.r. with the circuit. You should include a small cable strain relief grommet in the power and lights cable entry holes.

The power supply from the lights power supply transformer is connected directly to terminal block TB3, and the garden lights are connected directly to terminal block TB2. In view of the large current involved it is advisable to use these direct connections.

The power unit supplied with the garden lights should already have fuse protection (probably a thermal fuse) built in. If this is not the case then an additional fuse should be included in the supply linking the power input to pin 1 of terminal TB3. This will guard against a short circuit occurring in the cable feeding the garden lights.

The circuit board may be fixed into the case using p.c.b. self-adhesive supports, taking care to align the l.e.d.s with the holes in the case.

## TESTING

Commence the testing procedure by connecting the l.d.r., but avoid connecting the garden lights or garden power unit at this stage. Testing the circuit with a 12V d.c. supply limited to 1A or less, will ensure less damage if mistakes have been made. A 9V PP3 battery should work in this application and is even less likely to cause damage.

When power is applied, one of the l.e.d.s – probably D2 – the green Daylight indicator should light. This at least indicates that all is likely to be well.

Partly shade the l.d.r. and press switch S2. Continue shading the l.d.r. The yellow (Lights-On) indicator D3 should light, followed by red D1 (Night). Unshading the l.d.r. should force the system back to green (Day). Each time D3 switches on or off the relay should click.

Further testing is difficult because of the long time delays involved. A 47k potentiometer, wired as a variable resistor, fitted in place of the l.d.r. will enable controlled testing as described under the Fault Finding section.

If all is well, double-check that capacitor C3 is the correct way round, since this is the only component that could explode if wrongly fitted! Connect the garden lights to terminal block TB2, and connect the high-current 12V a.c. (or d.c.) supply to TB3.

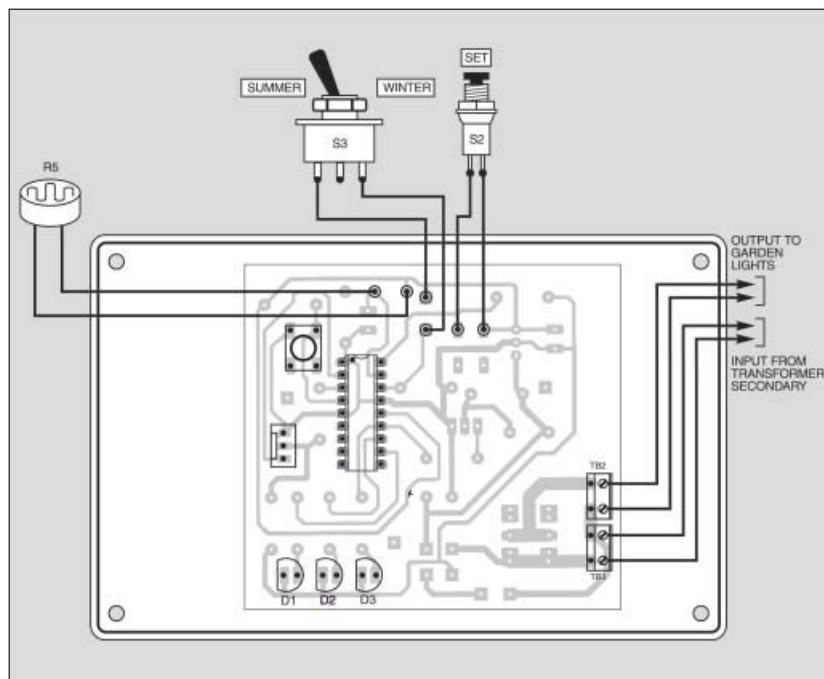


Fig.4. Interwiring details from the circuit board to off-board components.

## FAULT FINDING

Testing any timing circuit can be a little tedious, especially one designed to operate in a 48 hour cycle. Remember that the system measures the length of the first night in order to switch off half way through the second night.

Begin any "fault finding" by making simple voltmeter readings, starting with the voltage reading across pin 5 (GND) and pin 14 (+VE) of IC1. This should be close to 5V. A higher reading probably indicates that the regulator IC2 is at fault, or the wrong way round.

Connect the negative of the voltmeter to the d.c. 0V line in the circuit – noting that neither of the inputs to TB3 are at 0V. A suitable 0V (GND) point is the cathode (k) side of any l.e.d. Now take readings at the other pins on IC1, according to the circuit description at the beginning of this article.

If you need to test the circuit in a controlled way, begin by temporarily replacing the l.d.r. with a 47k variable resistor (potentiometer). This will allow you to control day and night more easily. A low resistance setting will simulate daytime. Set the variable resistor to half way, and press pushswitch S2. Now increase the resistance to simulate night-time.

## TIME LAPSE

The main timing loop takes just under six minutes per cycle. So when testing, you need to simulate a night lasting for at least 12 minutes in order to provide a rough guide as to whether the circuit is working. Be aware, however, that the time subtracted during summer-time is one hour, and so either set the circuit to winter-time by closing switch S3, or allow at least two hours of simulated night.

If you are programming using PICAXE, you can speed up the program by about 100 times by reducing the 'pause 1384' to 'pause 13'. This will allow testing for times of as little as 10 seconds, though two

minutes or more is recommended to avoid problems caused by the "summer time subtraction".

Note that the Summer/Winter switch S3 is best set to winter, since a value of 'pause 13' will cause 32 seconds to be subtracted from the night-time calculation, and this may cause confusion. Setting S3 to winter, i.e. closing S3, will prevent the 32 seconds subtraction. Of course, if S3 has been omitted, then the subtraction will always occur and you will need to remember that the switch-off time will be 32 seconds shorter than expected.

## FINAL SETTING-UP

The system is best set up during daylight, so that pushswitch S2 can be pressed at dusk. If you have already tested the p.c.b. as described earlier, then you can re-set the point at which the lights switch on either by pressing S2 at an earlier time, or by pressing and holding S2 if you wish to set a later time. This is described in detail in the Operating Instructions panel.

The l.d.r. should be fixed against the inside of a window, and should be shaded against direct sunlight since this will eventually damage the device. Avoid a position in which the l.d.r. may be fully shaded by somebody walking past, or a position in which direct light from the headlights of cars might pose a problem.

The prototype devices proved fairly immune in this respect, and street lights etc., were not a problem. Remember that the system will only provide an accurate calculation for switching off the lights, on the **second** and subsequent nights.

## HOW THE PROGRAM WORKS

The PICAXE (BASIC) program (called 'glight10') will be described. The HEX version, also available for download was derived from the same original, with minor alterations ('glight11'). So, for PICAXE

## OPERATING INSTRUCTIONS

1. During daylight, connect power to the system. The green (Day) l.e.d. should light.
  2. Wait until dusk, and press Set button S2 at the desired moment to switch on the lights. (Note that the anti-bounce feature of the system may require you to hold the button for a brief period, before the circuit responds). The yellow (D3) and red (D1) l.e.d.s should light. Red indicates Night, and yellow indicates the garden Lights should be on. The system will now measure the length of the night.
  3. During the first night, the garden lights will stay on for around 4 to 5 hours, but the following night the garden lights will switch on as set the first night, and will stay on until around midnight (i.e. half the length of the night).
  4. Switch the lamps off at any time by pressing S2 until the yellow l.e.d. (D3) switches off. Release S2 immediately. Note that the system will continue to measure the length of the night. If you do not release S2 immediately, the green l.e.d. will light indicating that you have reverted to daytime. The previous night's length will be retained.
  5. The Summer-Time switch setting (S3) will cause the lights to switch off one hour earlier, i.e. at midnight during summer time. This is the default setting i.e. if S3 is not fitted.
  6. Note that both the "lights-on" and "length of night" settings are saved in EEPROM. Hence if power is lost, or if you press reset, the settings will be retained.
- ### 7. CHANGING THE SETTINGS
- To set the lights to switch on earlier: Simply press S2 at the desired moment.
  - To set the lights to switch on later: At the required moment, press and hold S2 until the system toggles to daylight (green l.e.d.) then back to 'lights on'.

use 'glight10', but if you wish to use a conventional programmer, then use the hex file provided.

We cannot provide an assembly code listing of the hex version since this would break copyright rules, as each line of BASIC is converted to an assembly sequence designed by Revolution Education. If you wish to convert from BASIC to assembler it is necessary to buy a (modestly priced) Revolution Education programmer. Note however that certain lines in the BASIC listing are not supported by the conversion process, e.g. 'divide by 2' and 'readadc'.

### PICAXE-18 BASIC LISTING

The program begins with the command 'start:' followed by some settings read from EEPROM. Hence if the circuit is switched off, the settings will be retained. The value of b3 (light level) will be zero initially, but an initial value of zero for b4 (length of night) will cause an error, hence b4 is made 50 when the circuit is first switched on.

When the 'dark:' loop is entered, the green l.e.d. is switched on (high 6). The program reads the light level at input RA0 (readadc 0,b0) and places the result in variable b0. If this value is less than the stored value (b3) then the lights are switched on, otherwise the program loops back to 'dark:'.

If input RA1 is made high by pressing S2, the program jumps to 'hold:'. This copies the value of b0 into the variable b3. It also writes the value into EEPROM memory allocation 0 (write 0,b3). Hence the value set will always be remembered, even during power loss.

The label 'switon' switches on the lights (high 7). The system then enters two loops, 'loop1:' and 'loop2:'. The combination of the two loops allows the system to time for up to 24 hours, yet still check at roughly one-second intervals, whether S2 has been pressed. (Interrupts as used in assembly code are not available with PICAXE devices; hence the switch must be checked repeatedly within the loop).

The system now times the length of the night from the point at which the circuit registered dusk, to the same light level at dawn.

'Loop2:' simply counts from 0 to 250, pausing 1.384 seconds per loop. It also turns on the red l.e.d. (high 5), reads the light level to check for dawn, and checks whether S2 has been pressed. After 250 loops it returns to 'resetb2:' and variable b1 is incremented. If b1 exceeds the value of b4 then the system jumps to 'switoff:', and the lights are turned off.

Once the light level at dawn is equal to the dusk level set the previous evening (b3) then the program will jump to 'setb4:'. Now the lights are switched off (if they haven't already been), and variable b4 is set to half variable b1. Hence the length of the night (b1) is halved so that the lights will switch off at midnight in future.

A manual over-ride is provided, whereby, if S2 is pressed, (pin1 = 1) before the automatic switch off time, the system will jump to 'switoff:', so that the garden lights are turned off, then allowing the system to return to 'loop2:' and continuing the timing operation. If S2 is held down, the system will jump to 'delay:' which reverts back to the daylight loop without measuring the length of the night.

### SUMMER/WINTER

An error occurs during summer time, where the point at which the lights would turn off is 1 a.m. since this is half way through the night. Hence the line 'let b4 = b4-10' reduces the value of b4 by 1 hour to correct the error. However, in winter time the error does not occur and so if switch S3 is closed (pin7 = 1) the system jumps over the 'let b4 = b4-10' command.

The value of b4 is written into EEPROM memory allocation 1 (write 1,b4). Hence if power is lost, or reset is pressed, the system will still remember the length of the night.

### POWER CUTS

The program has been designed for "power-up" during daytime, and if a power

cut occurs during the day, the light and night-length settings stored in EEPROM will ensure normal operation when power is restored. However, if power is restored at night, the system will calculate the night-length from the moment of power-up, so causing an error.

Hence, variable b6 is used to inform the program whether power is restored during daylight or night. If power-up occurs during the day, the 'dark:' loop will cause b6 to be set to 1. If power up occurs at night, b6 will remain at 0, and at the label 'setb4:' the system will skip back to 'dark' without setting b4. Therefore, the previous night's calculation will be used for the following night.

### RESOURCES

The hex file can be used by readers to program PIC16F627 devices, using their own PIC programming hardware. It should be noted, however, that readers who wish to modify the BASIC program to suit their own requirements need to use the PICAXE programming software and serial lead that is available from Revolution Electronics, Dept EPE, 4 Old Dairy Business Centre, Melcombe Road, Bath BA2 3LR. Tel: 01225 340563. Email: info@rev-ed.co.uk. Web: www.rev-ed.co.uk. (This software is *not* available from EPE). They also supply blank PICAXE-18 microcontroller i.c.s.

The BASIC and hex files are available for free download from the EPE ftp site. This is most easily accessed via the main page of the EPE web site at [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk). At the top is a click-link saying FTP site (downloads), click it then click on PUB and then on PICS, in which screen you will find the Garden Lights folder.

The software can also be obtained on 3.5-inch disk (Disk 6) from the Editorial office. There is a nominal handling charge to cover admin costs. Details are given on the EPE PCB Service page, and in this month's *Shoptalk*, which also gives details about obtaining pre-programmed PICs.



## **April 2003 – Special PIC Supplement**

This special 16-page supplement is available for free download from the EPE Online website.

All you have to do is bounce over to [www.epemag.com](http://www.epemag.com) and click on the “Library” link in the main navigation.



# New Technology Update

*Improved fabrication processing promises increased memory cell capacity. Ian Poole reports.*

**M**EMORY is one of the major elements in today's electronics scene. Equipment from mobile phones to games consoles, and PC cards to organisers all use increasing amounts of memory.

One area in which several strides forward have been made in recent years is for system-on-chip (SoC) designs. Already the level of memory usage in these highly integrated devices has grown considerably and this means that the spotlight is firmly fixed on this area of the technology.

## More For Less

Most of the designs for these systems use memory cells that employ the traditional six transistor SRAM cell. So great was the demand for memory that an SoC design typically utilised over 20% of its area purely for memory.

In response, a company named MoSys developed a new memory cell in 1998 that used only one transistor. Named 1T-SRAM, it has many similarities to a dynamic RAM (DRAM) having only a single transistor in its topology.

As it has fewer transistors in the basic cell, 1T-SRAM technology gave a two-fold improvement in density. This was a particularly valuable improvement as it enabled much better utilisation of the chip area. It also gave, it is claimed, cost reductions of between 50% and 70% as it used some metal layers rather than all polysilicon ones.

With the large costs involved in introducing new processes into semiconductor manufacturing plants, the fact that traditional CMOS processes can be used is of considerable importance.

A further advantage of the 1T-SRAM technology is that it requires less power than the traditional six transistor SRAM cells. It uses around 75% less power, a factor that is very beneficial. Not only does it mean that there is less drain on the power supplies, an important factor in many of today's designs, but it also assists in the design of the chips as less heat has to be removed.

The memories maintain compatibility with other memories and architectures through the use of the familiar SRAM interface. The MoSys system of partitioning the memory into large numbers of small banks allows the refresh cycle to take place transparently in the background. By providing a cache, even the banks that are frequently accessed can function in this mode. This enables a very fast random cycle performance with low power consumption, and full compatibility with standard logic processes.

## Further Developments

The next stage in the development of the technology was to provide an even lower level of power consumption. This was achieved at the beginning of 2001 with the introduction of their 1T-SRAM-M. This development introduced a leakage suppression circuit that enabled a standby current of only 10 microamps per Megabit of memory to be achieved.

With the rapid increase in demand for this type of memory, further developments were made in 2002 when a new improvement to the technology was launched. Called 1T-SRAM-R it included further features including a new technique called Transparent Error Correction. This is a patented MoSys development that enabled repair during manufacture, or a slower self repair at power up.

## Latest Generation

The latest stage in the evolution of this memory technology has been achieved with the introduction of the new MoSys 1T-SRAM-Q memory. This development provides four times the density of normal six transistor SRAM and is still able to provide excellent scalability to future nanometre scales.

The new technology achieves its performance by "folding" the capacitor in the basic memory cell as shown in Fig.1. Using this technique it is possible to reduce the size of the basic memory cell

whilst still providing the same charge storage as in the previous 1T-SRAM capacitor.

The new technology offers further improvements by providing an improved ratio of stored charge to parasitics. This enables a much better signal-to-noise ratio to be achieved that ultimately results in fewer data errors.

The smaller capacitor also results in an improved ratio of stored charge to cell circuitry giving a reduced level of power consumption. The shorter wires, fewer parasitics and lower voltage all result in lower levels of power dissipation. As a result the overall power consumption of the cell can be reduced without impacting on its speed or reliability.

## Fabrication

The new folded capacitor results from the use of a new capacitor topology. Rather than just stretching it horizontally, the capacitor is extended in the vertical plane.

An additional mask is used in the fabrication process, along with two additional steps to etch a well in the shallow trench isolation layer. This well is then filled with polysilicon. Oxide forms naturally, bending the horizontal capacitor plate down into the well.

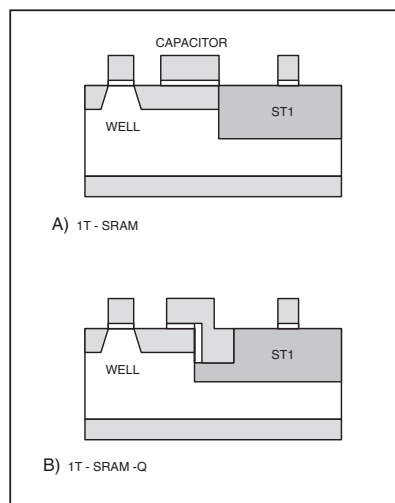
The capacitor retains a large effective area, even when the cell structure is scaled down. It has also been shown to be very robust, a critical feature in memory applications. This issue could have been of concern because bends in the plate could increase the electric field to a point where breakdown might occur.

## Optimistic

The process has been optimised so that the additional etch and implant steps occur before the transistors are fabricated. This is an important feature because it means that the active devices do not undergo any additional thermal cycles.

Thermal cycles affect the performance parameters of the transistors and accordingly the development engineers have been very confident that the new process has not had any impact on the performance of the basic cell.

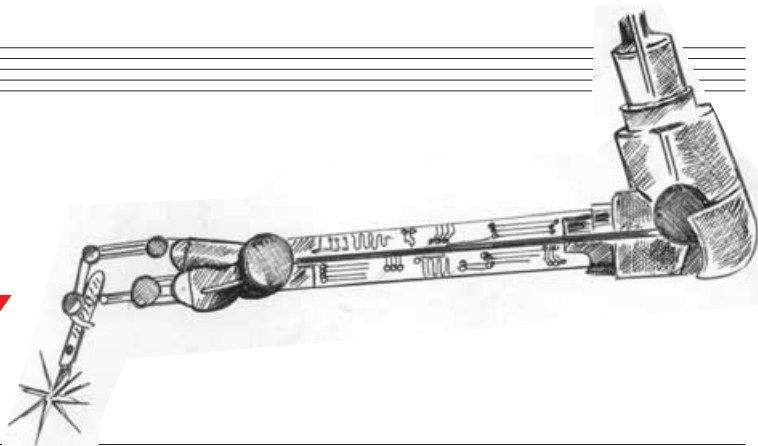
Although two additional steps are required in the fabrication process this only adds about 5% to the manufacturing cost. Against this, the size reduction means that the overall costs fall, typically by about 25%. This is a real achievement in today's semiconductor industry where much smaller cost improvements are seen as major breakthroughs.



*Fig. 1. Comparison of the new cell with the folded capacitor and previous generations*

# CIRCUIT SURGERY

ALAN WINSTANLEY  
and IAN BELL



*This month we explain how to read circuit diagrams and suggest a CMOS op.amp solution for a reader's application.*

## Circuit Guide

Can anyone recommend a really good book that deals with how to follow and understand circuit diagrams? This is needed for some GNVQ coursework. Thanks from **John**. Posted in the EPE Chat Zone message board ([www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk))

Circuit diagrams often bemuse newcomers to electronics. Experienced constructors can read them like a book and after tracing a few lines around with finger and thumb, they quickly get to understand the "plot".

To beginners and novices though, a circuit diagram can be all but incomprehensible, so in this month's *Circuit Surgery* we start a short mini-series on how to interpret electronic circuit diagrams, highlighting some of the pitfalls that trap beginners along the way.

## Tour Guide

A circuit diagram is actually nothing more than a road map. If towns and cities are electronic components, then the lines on a map that represent the roads are simply electrical *conductors* – the wiring and interconnections that join everything together properly.

In electronic terms, we can join components together in two ways. We can use a

printed circuit board (p.c.b.) to carry most of the components, and the copper tracks on the board are then specially designed to connect the components together into a circuit.

Take a look through any of the project pages of *EPE* and you will see a wide variety of p.c.b. patterns, each created specially by the project's designer, probably using computer software. A p.c.b. does most of the hard work for you, and takes away much of the guesswork of assembly.

The second way of connecting parts together is obviously to use ordinary copper wire. This is necessary to connect printed circuit boards to any larger off-board components (e.g. controls or plugs and sockets) in a process often called "interwiring". Obviously, entire circuits could be built by using wire conductors, but a printed circuit board is far more compact and reliable, and offers a much higher chance of the circuit working first time.

## Road Sense

In circuit diagrams, conductors are represented by solid lines – just like the roads on a road map. The lines in a circuit diagram are therefore the copper tracks on a p.c.b. or the wires that interconnect parts to each other. One problem with circuit diagrams, however, is that we cannot tell whether the

solid line is the equivalent of a motorway or just a narrow country lane: they are only shown as *conductors* (roads)!

We have to read the diagram to see whether a conductor is carrying a small audio signal, or whether it's driving a heavy mains voltage load, or carrying vast amounts of high-speed data. The difference is critical when it comes to assembling a project, because we have to ensure that the correct type of cable or wire is used, that it is routed properly and that adequate insulation is used where necessary.

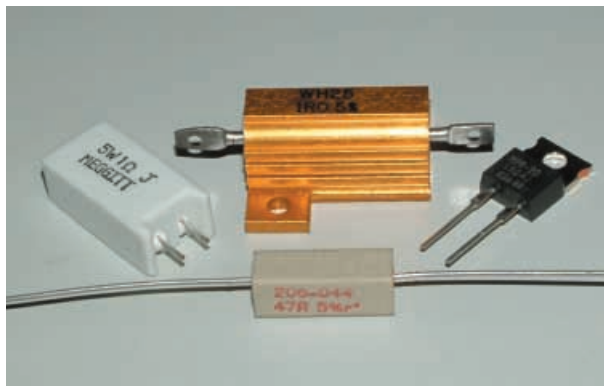
So the first point to bear in mind is that circuit diagrams cannot show all the *practical* information that we might need during construction: circuit diagrams are just two-dimensional schematic, to show which parts are connected where! You should therefore read the entire project details and components list carefully, noting any unusual practical requirements along the way. (In *Shoptalk*, we give you any important buying tips or late-breaking news, and it should always be checked carefully.)

## Missed a Blobby

The amusing but anarchic character "Mr. Blobby" is known on UK TV for causing chaos and damage, and that is exactly what happens in an electronic circuit when we get our wires crossed (literally).



Left, panel (chassis) mounting rotary potentiometer, top right: enclosed preset, open (skeleton) preset, multiturn, side adjust, preset "resistors".



A selection of high power resistors. Note the aluminium heatsink and the tab heatsink on the top two resistors.

To get a feel for how a circuit diagram can be read, in Fig.1 we have drawn some electronic components as boxes in a simple diagram. Their terminals are clearly labelled as 1, 2 or 3. The diagram illustrates how lines in a circuit diagram represent conductors, and how to show a *junction* (when conductors are joined together).

First, we can say that components A and B are in *parallel* with each other, because they are connected “across” each other like the rungs of a ladder. Components C and D are in series with each other, because a conductor is used to join terminal 2 of component C to terminal 1 of component D.

Then another part, component E, has been added as shown. Its terminal 1 connects to terminal 1 of components A, B and C, so two blobs (labelled “A” and “B”) are used to show that these conductors are all joined together. Terminal 2 of component E is connected with a conductor directly to terminal 3 of component D. Lastly, terminal 3 of E goes directly to terminal 3 of component B.

It is easy to see how lines can therefore be drawn to show how components are linked together with conductors. Note how

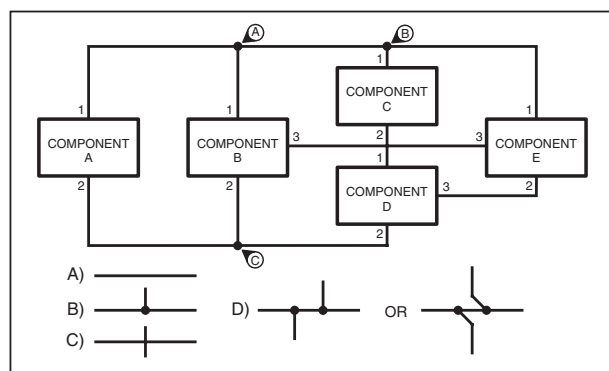


Fig.1. How to read a circuit diagram (see text). (a) conductor, (b) joint, (c) conductors cross but do not join, (d) preferred way of showing off-set multiple conductors joining together.

a blob shows a *joint*, while the *absence* of a blob when lines cross over means the conductors **do not join together**. Therefore, terminal 3 of component E does **not** connect to either C or D; it **only** connects to component B. Pin 2 of Components A, B and D are all joined together, hence the single blob labelled “C”.

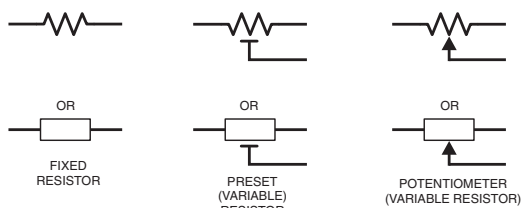
If we have two components joined directly together (e.g. C and D), we never show the component joints themselves with blobs because it's unnecessary. But when a conductor is joined to another (say by a solder joint or a screw terminal), the junction is clearly signified by a blob. The circuit diagram doesn't usually tell us what sort of wire to use, nor how thick, short or long the conductors should be: you have to read the article to find out.

## Highway Code

When it comes to describing electronic components themselves – the towns and cities on our road map – then *schematic symbols* are used to represent them in a circuit diagram. In the first of the “File panels”, Fig.2, to be included with this mini-series, we have set out some of the circuit symbol options used in *EPE* for resistors and capacitors.

## SYMBOL FILE-1

### RESISTORS



### CAPACITORS

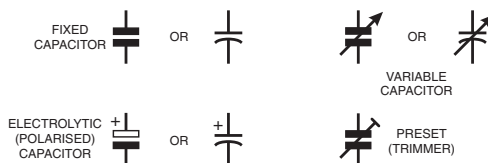


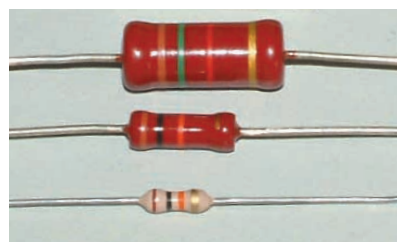
Fig.2. A selection of popular circuit symbols for resistors and capacitors.

In industry, either American ANSI standards or ISO/British Standard symbols will be seen, so we have shown some common variations. Note that *EPE* always uses the zig-zag symbol for resistors; elsewhere an equally correct rectangular version may be used.

Capacitors can also be shown in several ways; *EPE* uses the rectangular version as shown, but elsewhere a curved line is commonly seen, especial-

ly on semiconductor data sheets and application notes. Some capacitors are polarity-sensitive, so a plus-sign will be shown accordingly.

Next month, we will illustrate more conventions used in schematic symbols including popular semiconductor devices, possibly looking at more advanced circuit schematics as well. ARW



Example fixed carbon film resistors (top to bottom): 1 Watt, 0.25W, 0.5W.

## Dream On

Our thanks to *Noel Harvey* who emailed us about our 10-part educational series *Teach-In 2002* and our response to an earlier query regarding single supply versions of op.amp circuits. We are pleased to hear that our advice proved to be useful. Noel writes:

*Revisiting Teach-In 2002, thank you for your response to my query (Circuit Surgery, Nov '02, page 790) and especially the reference to Ron Mancini's Application Note. Yes, the single sided*



Polarised electrolytic capacitors, first two have “radial” leads and the third “axial”.



A small selection of non-polarised capacitors plus a miniature, p.c.b. mounting trimmer capacitor.



supply LM741 was extremely difficult to work with, especially in obtaining d.c. shift.

Changing to the TLV2472 has been a dream come true, no problems with either amplification or d.c. shift. One tip for other readers though, as fixed resistors are only available in widely spaced values, using good quality trimmer resistors in series with them in the feedback and reference voltage circuits enables one to tune the lower and upper amplification limits exactly (250mV and 4.75V in my case).

Regarding sensors though, your input on the following would be appreciated. Assume that one wishes to accurately measure the water level of a pond using a 5 kilohm voltage divider (RS Components Stock No. 319-310 "Rotary Position Sensor"). Obviously, there would be wind driven wavelets (irregular oscillations). Is there a simple method of designing an op.amp circuit to electrically dampen the effect of the ripples, so that the final meter reading is steady, without having to resort to a PIC?

Basically you require a low pass filter. The waves due to the ripples on the pond have a particular frequency (or range of frequencies), but this will be somewhat higher than the rate of variation of water level due to rain or evaporation. To design the filter, you need to know the approximate lowest frequency of troublesome ripples and the highest rate of change in water level that you would be interested in monitoring.

## Ripple Effect

The frequency of the ripples relates to the time it takes for the water level to go from a peak to the next peak at a particular location. This is the *period* of the wave; its reciprocal (one divided by this value) gives us the frequency.

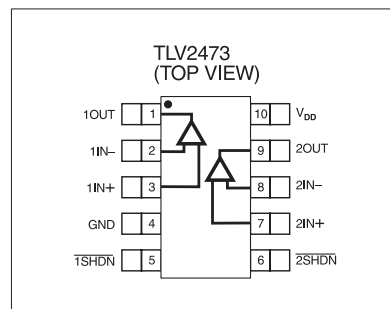
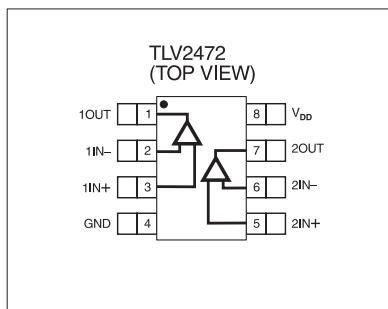


Fig.3. Pinout information for the Texas Instruments TLV2472 dual op.amp and the TLV2473 with a shutdown (SHDN) feature.

As an example, you may observe that the slowest ripples have a period of 4 seconds, or 0.25Hz. Let's assume that the fastest level changes you are interested in would have a cycle time of say 4 hours, which is about 0.00007Hz. Then you need a filter that cuts frequencies above 0.25Hz, but passes those at 0.00007Hz.

As these frequencies are widely separated you do not need a high order filter, and a simple first order RC filter should suffice. This filter can be driven from an amplifier or buffered version of the sensor signal, after which you can level shift to the required output range.

## Interesting Family

For the benefit of other readers, the TLV2472 is part of a very interesting family of CMOS rail-to-rail op.amps from Texas Instruments. The TLV247x chips contain 1, 2 or 4 op.amps, with each size available with a shutdown option during which the supply current is only 350nA per op.amp on a 3V supply.

The TLV2472 chips operate on supply voltages from 2.7V to 6V, and are low

power devices taking only 600μA per op.amp during operation. The outputs can swing to within 180mV of the supplies while driving up to 10mA into the load, and up to 35mA drive is available if rail-to-rail output operation is not required. Both inputs can swing rail-to-rail during normal operation; we covered the importance of this to single supply use in the Nov '02 issue.

Other similar single supply op.amps from Texas include the TLV245x family, which offers lower offsets and lower power consumption, but less bandwidth than the TLV247x chips. Also there is the TLV246x family, which has higher output drive capability. You can learn more by checking the Texas Instruments web site ([www.ti.com](http://www.ti.com)) and search for that part number from their home page.

The pinout of the TLV2472 used by Noel Harvey, which is the twin-op.amp member of the TLV247x family, is shown in Fig.3. Also shown is the TLV2473, which is the version of TLV2472 that has the shutdown (SHDN) controls. *I.M.B.*

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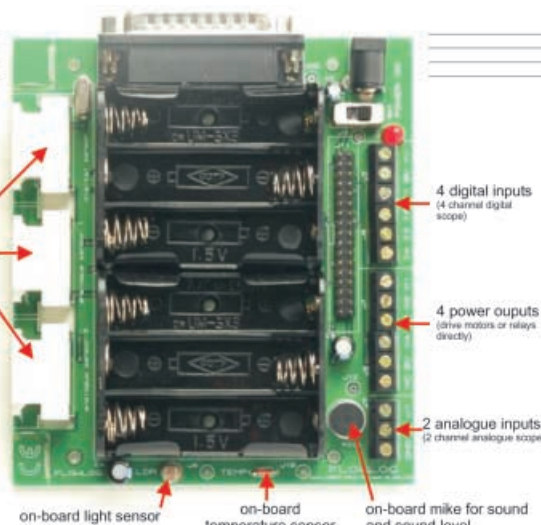
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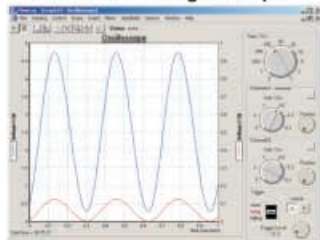
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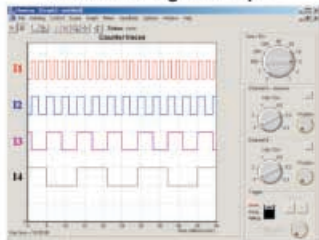


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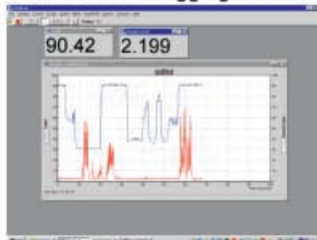
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# INTERFACE

## Robert Penfold



### UPDATE ON DIRECT CONTROL OF PC SERIAL LINES USING MSCOMM

**T**HE previous *Interface* article covered the subject of using the serial port handshake lines in conjunction with the MSCOMM ActiveX control. This produced a few emails from around the world pointing out that the article had been a bit "economical with the truth". It seems that MSCOMM can indeed do rather more than was suggested in the last article.

Thanks to those who took the time to send in details of the extra facilities that are available. In this article we will try to put the record straight, and provide more details about the use of MSCOMM with the handshake lines.

#### State Monitoring

As correctly pointed out in the previous *Interface* article, it is possible to count pulses applied via the handshake inputs. They can also be used as edge triggered inputs with certain transitions being detected.

However, it was incorrectly stated that there was no way of reading the state of these lines. It is in fact possible to do so, and for some applications it would be better to use this method of monitoring the handshake inputs.

To be more precise, it is possible to read the input state of three of the handshake inputs. The lines in question are CD (carrier detect), CTS (clear to send), and DSR (data set ready). As far as can be ascertained, there is no facility for reading the state of the RI (Ring Indicator) input.

These input lines are read using the following functions:

Line	Function
CD	CDHolding
CTS	CTSHolding
DSR	DSRHolding

All three return True as the value if the relevant line is high (+12V) or False if it is low (-12V).

To try out these functions place a label, MSCOMM, and a timer component onto a form. Make the label quite large, set a large font such as 24 point so that it is easy to see, and delete the default caption in the Properties Inspector.

Use the Properties Inspector to set a short Interval value for the timer component, such as 20ms or 25ms. MSCOMM will use COM1 (serial port 1) by default, so use the Properties Inspector to set the CommPort value at 2 if you wish to use COM2.

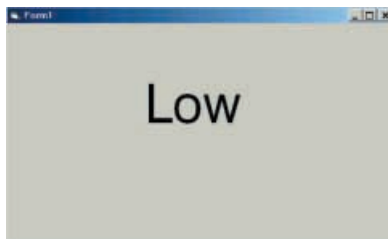
#### CTS Input

The following two short routines for the form and the timer are all that is needed to make the label show the state on the CTS input:

```
Private Sub Form_Load()  
    MSCOMM1.PortOpen = True  
End Sub  
  
Private Sub Timer1_Timer()  
    If MSCOMM1.CTSHolding = True Then  
        Label1.Caption = "High"  
    If MSCOMM1.CTSHolding = False  
    Then Label1.Caption = "Low"  
End Sub
```

The single line of code in the subroutine for the form simply switches on the serial port. The routine for the timer uses two If...Then instructions to check the state of the CTS line and set the correct caption on the label component.

The first one sets the caption as "High" if the returned value from CTSHolding is True. The second one sets the caption as "Low" if the returned value is False. As there are only two possible values this could actually be reduced to a single If...Then...Else instruction if preferred.



*Fig.1. Unconnected handshake inputs normally drift to the low state.*

When the program is run, the label will almost certainly indicate that the CTS input is Low (see Fig.1). Serial port inputs do not usually have any pull-up or pull-down resistors, and simply drift to about zero volts with no input signal.

Practically all serial ports interpret zero volts, or anything less than about one volt, as a low input level. The nominal input levels for an RS232C serial port are  $\pm 12V$ , but applying anything from about +3V to +15V to the CTS input should be sufficient to change the reading on the label to High.

Driving the CTS input with normal logic levels from (say) the parallel port will probably be sufficient to produce a change in the reading from the program. Alternative methods are to use a 9V battery in series with a one kilohm (1k) current limiter resistor, or to simply use one of the serial port's handshake outputs set to the high state. Whatever the signal source, the caption on the label should change to "High", as shown in Fig.2.

Substituting CDHolding or DSRHolding for CTSHolding in the appropriate two lines should make the program respond to the CD and DSR lines respectively. Being able to monitor the state of these three input lines is certainly a useful feature, but it does not necessarily represent the best way of doing things. The method of monitoring described in the previous *Interface* article is often preferable for applications that require pulse counting or a hold-off until a certain transition occurs.

#### Additional Output

I am grateful to *Muhammad Asim Khan* for pointing out that there is actually a third output available from a PC serial port. There are only two handshake outputs, which are DTR (data terminal ready) and RTS (request to send). However, it is possible to use the TXD (Transmission Data) line to act as a third output.

It can be controlled via MSCOMM.Break, which is set to True in order to set the TXD line at +12V, or False to set it at -12V. Of course, transmission from this line in the normal manner is not possible if it is controlled directly.

This extended version of the previous program demonstrates the use of this facility:

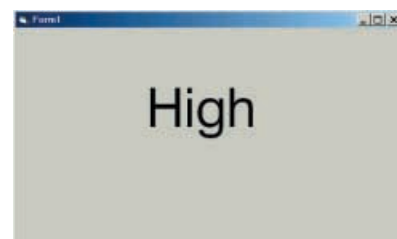
```
Private Sub Command1_Click()  
    MSCOMM1.Break = True  
End Sub
```

```
Private Sub Command2_Click()  
    MSCOMM1.Break = False  
End Sub
```

```
Private Sub Form_Load()  
    MSCOMM1.PortOpen = True  
End Sub
```

```
Private Sub Timer1_Timer()  
    If MSCOMM1.CTSHolding = True Then  
        Label1.Caption = "High"
```

```
    If MSCOMM1.CTSHolding = False  
    Then Label1.Caption = "Low"  
End Sub
```



*Fig.2. Taking the CTS input to +9V has produced the correct response from the program.*



Two buttons must be added to the form, and these have the captions changed to "High" (Command1) and "Low" (Command 2). The default text size is a bit small so it is advisable to increase the font size to about 18 points. This gives something like Fig.3, which shows the program in operation.

Left-clicking the High button sets MSComm1.Break at True, and the TXD output at +12V. MSComm1.Break is set to False when the Low button is operated, which sets the TXD output at -12V.

The easiest way of checking that the TXD output is changing state is to couple this pin to the CTS input of the serial port. With a 9-pin serial port it is easy to connect these two pins by fitting a miniature crocodile clip over them. Connection details for the 9-pin and 25-pin versions of a PC serial port are shown in Fig.4.

With this link in place, the label's caption should change each time the output state is changed using the two buttons. The label will revert to the default Low reading with the link removed, and the buttons will then have no effect on the label.

### Online Library

It is possible to control the state of the TXD output line, so is it possible to read the state of the RXD (Receiver Data) input line? Reader *Jerry McCarthy* provided this useful link to the MSCOMM page of Microsoft's online library:

[http://msdn.microsoft.com/library/default.asp?url=/library/en-us/comm98/dt\\_vbobjComm\\_P.asp](http://msdn.microsoft.com/library/default.asp?url=/library/en-us/comm98/dt_vbobjComm_P.asp)

This page provides a full list of the MSCOMM functions, with a link to a brief description and further information for each one. There does not appear to be anything in the list that permits the RXD input line to be directly monitored.

I have not gone through all the bits of the 16550 UART's registers, but it seems likely that this facility is not in its repertoire. Anyway, four inputs and three outputs might seem meagre compared to the parallel port, but there is still plenty of scope for simple applications such as relay and motor control.

### Big Advantage

More ambitious projects should also be possible. With standard UARTs such as



Fig.3. The modified program will read back the level set on the TXD output line.

the 6402 now "a bit thin on the ground" a simple synchronous interface to serial DACs, ADCs, and shift registers is perhaps a more practical approach than inputting and outputting data in the conventional manner.

Interfacing (say) a 12-bit serial DAC and an 8-bit serial ADC to a serial port should not be too difficult. Bear in mind that most modern PCs have two serial ports, neither of which are actually used any more. Two serial ports provide a total of eight inputs and six outputs. Used in the right way, these give massive scope for interfacing projects to a PC.

MSCOMM might have its limitations, but it does have the big advantage of working with any 32-bit version of Windows, including Windows 2000 and XP. With many PCs now supplied with Windows XP rather than Windows ME installed, this is increasingly important. Remember that the MSCOMM ActiveX control must be available to the compiled programs that make use of its facilities. If your version of Visual BASIC came complete with MSCOMM, then you are licensed to use and distribute it with your programs.

### Limitation

The main limitation of using MSCOMM and the serial ports is that data cannot be input or output at high speed. High speed serial interfacing requires input/output frequencies of many megahertz. Ordinary serial chips and line drivers/receivers are not intended for operation at anything approaching that sort of rate.

An RS232C serial port can output data at up to about 10 kilobytes or so per

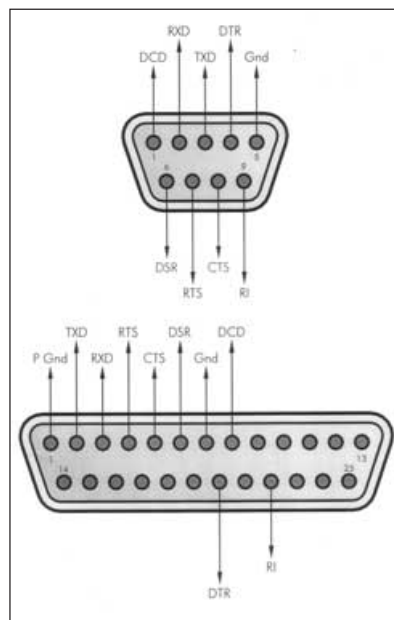


Fig.4. Connection details for 9-pin and 25-pin PC serial ports.

second when used conventionally. It might be possible to go slightly higher than this when using the handshake lines in a synchronous serial link, but a vast improvement is unlikely. Fortunately, there are many applications that do not require transfers at more than about 10 or 20 kilobytes per second.

Ordinary logic outputs will usually drive RS232C inputs successfully. At worst the add-on will simply fail to work.

When designing serial port projects it is essential to bear in mind that the output voltages from an RS232C could potentially zap many devices that are intended for use with 5V logic levels. Also, bear in mind that the actual output voltages can be somewhat more than the nominal  $\pm 12V$  volt levels, which are more than adequate to damage many logic chips anyway.

Interfacing the serial port lines to ADCs and other devices that operate at normal logic levels will be covered in the next *Interface* article.



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# READOUT

Email: [john.becker@epemag.wimborne.co.uk](mailto:john.becker@epemag.wimborne.co.uk)

**John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!**

All letters quoted here have previously been replied to directly.

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## ★ LETTER OF THE MONTH ★

### WIND SPEED METER

Dear EPE,

I greatly appreciate John Becker's *Wind-speed Meter* article in the Jan '03 issue. Some time back, as the first step in designing an autonomous house for a difficult site (north slope, coastal Donegal), I thought that a year of local weather data would be useful. The suite of parameters I wanted is much like John's Weather Centre he's doing (but no soil moisture: there's standing water on 30° slopes during the two-week dry spell in August).

I designed an ultrasonic anemometer at the mathematical level, persuading myself that I could obtain 0.1m/s and 1° angular resolution. But our electronics lab, having been obliterated in favour of administrative offices, made no effort at construction. My current thinking favours triangular sensor placement, as in some commercial anemometers.

Creagh House (near Ballinrobe) occupied a third of an acre when it was built in 1870, but half of it burned down in 1930, and the remainder was last used as a research station by the Forestry Dept., ca. 1980. Clearing out a back room over a weekend, I came across a vintage cup anemometer painted in battleship grey, suitable for driving a speedometer cable down to the ground floor (or bridge, depending). With a bit of elbow grease it has become found art in gleaming copper, brass and bronze. Lovely device!

For remote data collection I have an Onset 4-input Hobo data logger, currently gathering only indoor and outdoor temperature, with a Motorola MPX4115AP barometer waiting in the wings. I still need an RH sensor – although 100% is not a bad estimate at any given time. Onset sells a "data shuttle" which carries data back to my Macintoshes, and offers free Boxcar software to process it. I then appropriate the data arrays for my own analysis and, eventually, house-management program.

The question of remote rainfall measurement with no moving parts is challenging! I belong to Nat. Uni. Ireland Galway's Environmental

Change Institute, and we discuss such things carpooling to work. One approach contemplates a V-weir in the roof-drain, sensed by a capacitive level sensor – but there's the problem of compatibility with a system that collects data at prescribed times and turns on its sensors 15ms before reading them.

Onset's approach to rainfall is a separate event logger, [www.onsetcomp.com/Products/3648\\_event.html](http://www.onsetcomp.com/Products/3648_event.html), which records times from a tipping bucket. I will be very interested to see what John comes up with! (I see that Onset now sell a small weather station with cup anemometer and tipping bucket that runs for a year on four AA cells.)

As an American, I was impressed by the number of ads for prototyping boards in *EPE*, but disappointed to discover that they invariably talk to computers that I haven't touched for 20-odd years, in a language of no distinction at all. Nothing for Macs in Forth! Bizarre! (I disliked Bill Gates and his work by 1978, and have used nothing of his since. One benefit has been complete freedom from viruses; another is working software.)

Keep up the good work.

**Ferren MacIntyre, via email**

*Hi again Ferren, many thanks for your interesting comments (and for the personal emails we exchanged!).*

*I'm not sure my maths is up to doing triangulated wind speed sensing, but it's an interesting thought. I'm using 4-quadrant sensing. Rain I'm intending to sense ultrasonically as well, probably a mixture of phase shift of the Ux signal and distance sensing, in relation to the surface of water in an open container. My intention is to have no moving parts whatsoever in this design. I've done mechanical weather designs in the past and now want to move on!*

*We principally support Gate's products as most readers have them, but we do periodically get yells of "Bill's broken my Windows again!"*

### DUCK OR GROUSE

Dear EPE,

Recently I read your Feb '01 Supplement on *Using Graphics LCD Displays*. The information that you have provided is excellent.

I have tried your code on a Toshiba GLCD, model TLX-1013-E0. This is slightly bigger compared to the PG12864 you used. Its resolution is 160 by 128 pixels, and it is also controlled by the T6963C. Your Demos work well on this I.c.d., except for Demo 8, which I could not get to work because I do not know how to include the **DUCK08.MSG** file using my Microchip PICStart Plus programmer. Please could you kindly advise.

For your information, the TLX-1013-E0 datasheet can be downloaded from the Internet. I keyed in Toshiba, LCD, TLX in the Yahoo search engine which led me to the datasheet. The pins layout is slightly different from the

PG12864. Furthermore, the contrast pin for TLX-1013-E0 needs about -7.5V for its display contrast setting.

Using your code directly on the TLX-1013-E0, it displays only on the upper half screen, with garbage being displayed on the lower half. The lower half screen's start address is at H8000 and the garbage can be easily cleared by your Clear routine set for this address.

**Tan Lawrence, via email**

*I am not familiar with PICstart, Lawrence, and cannot offer you a positive opinion. However, it seems likely that it can accept data statements within ASM files for direct loading into the PIC's Data EEPROM when the main program is downloaded into the PIC. If so, you could enter the Duck data as such statements. Have a chat with Microchip via [www.microchip.com](http://www.microchip.com), or your PICstart's suppliers.*

### INTERFERENCE

Dear EPE,

Regarding the *News* item about Tetra safety (Mar '03) – it is about time the makers of medical equipment, etc. got their act together. Surely they must realise that they live in the real world where spurious radiation leaks out and always will. Mobile communications equipment are a fact of life, but as usual, elementary screening precautions go out of the window in favour of cost reduction.

For example, a large London research hospital enclosed an operating theatre with chicken wire thinking it would suppress interference. It didn't, especially as there were no signal filters in the various service lines in and out, also the doors were just wood. Proof of the pudding is, if a radio works inside a room it is not screened.

Here are some instances of manufacturing stupidity: Large CCTV cameras were letting interference in because the metal lens assembly was separated from the screened box by a layer of paint. Scrape off the paint and let the lens case bind to the metal and problem solved. Hi-fi gear that just needed a tiny capacitor across the input amplifier lead to stop it pretending it was a wide band amplifier and picking up all that was there.

Some years ago an American pressure group showed a plan of cancer deaths along a microwave link path. Anybody who knows even a little bit about aerials knows that several radiation side lobes exist, yet there were no cancers marked except in the straight line between A and B. Called selective reporting I believe.

Then you see staff with mobile phones, pagers and even old fashioned walkie talkies, and ambulances outside the accident and emergency dept with powerful transmitters reporting back to base, one wonders if the whole question is not a tiny bit hyped up.

I used to be involved in the design of screened rooms and the boss wrote a book about screening problems and solutions. First line was, you can suppress anything if you have a big enough hammer.

**G.S.Chatley, via email**

*The jury seems to be still out on all of this G.S. But even if it does come out against any form of electromagnetic radiation, on the basis that it is injurious to health, could society accept and implement its judgement? Society would crash if it did. The best we can do is limit our exposure to such radiations. I for one do not wish to have a transmitter next to my brain for any longer than is necessary and only use a mobile phone when essential. It grieves me to see them in such widespread constant use, especially next to the brains of young children.*

*On a more mundane level, when I was still in film making, one of the recording theatres I used had problems with radio taxi transmissions breaking into the amplifier circuits. Chicken wire did solve that one, but the entire building had to be enclosed.*

### SERIAL EEPROM USE

Reader **Gary Moulton** has kindly presented us with a software discussion, complete with example program listing, about using serial EEPROM chips with PICs. This has been placed on our FTP site in the PIC Tricks sub-folder of the main PICs folder, under the title *Using Serial EEPROMs*.

Many thanks Gary, your gift is appreciated.



## P.C.B. CAD

Dear EPE,

It seems a long time since there was a review of p.c.b. layout software in *EPE*. I haven't found it that easy to find simple, cheap, hobbyist shareware stuff by searching the web. Most trawls I try throw up heavyweight professional CAD/CAM packages which do schematic capture, multiple layers, autorouting, gerber output, and have price tags to match.

I currently use a particular p.c.b. CAD package that I bought some years ago. I've been reasonably satisfied with this software – it does most things I need it to – but the PC I run it on is beginning to show its age now. It's slow by today's standards, about one time out of three it fails to boot properly, and the incidence of funny crashes and blue screens is increasing. I fear that before too long I'm going to have to face up to the issue of replacing it, before it becomes impossible to buy PCs with serial and parallel ports on them at all.

I'm dreading this because I'm going to have to make decisions like whether to stick with Win98SE, which I run now and know fairly well despite all its shortcomings. If I do that all my existing stuff should run OK, but I'll be increasingly cut off from newer apps and interfaces that will increasingly tend to be written only for XP. Or I could change to 2000 or (heaven forbid) XP. For better or worse these are the way forward and I probably can't resist progress forever. But I'll no doubt have trouble getting some of my existing old and well-loved programs to run on a new PC, including my p.c.b. layout program. Hence I'm wondering about possible p.c.b. CAD replacements.

Maybe it would be a topic one of your regular authors might like to look at sometime.

**Malc Wiles,**  
via email

*Hi Malc, I know this is something we have discussed in private emails, but readers could be interested in a summary of the discussion.*

*You've hit on a bit of a thorny problem. Everyone who's into writing for EPE will already have their own favourite p.c.b. CAD. The research time for other packages would not really be viable for them to do reviews of the various options available.*

*The best advice we feel we can currently offer readers is that they obtain the free demos from those who do p.c.b. CAD and judge for themselves. It is acknowledged, though, that information about what to look out for in such packages would be highly beneficial to those who have not yet got into p.c.b. design software. Maybe this is an area that we could cover in general terms sometime. Thanks for the suggestion.*

## BLOWING IN THE WIND

Dear EPE,

I've read John Becker's *Wind Tunnel* article (Feb '03) as I was interested to know how he was going to control the speed of an induction motor. Not a trivial task, as he has found.

I am hardly surprised by his findings of motor characteristics at different frequencies. As most people know, mains a.c. motors are designed to run at 50Hz (or 60Hz). Below this frequency the inductive reactance of the winding gets less and less so leading to a rapid increase in current, largely limited by the d.c. resistance of the winding. Above 50Hz the inductance of the winding plays a greater and greater role in limiting the maximum current and hence maximum torque available, this coupled with increasing iron losses is why the speed actually reduces as the frequency increases above 100Hz.

Three-phase motor speed controllers (known as frequency inverters) vary the output voltage as well as the frequency and for fans the output would be set to the square law voltage/frequency curve. One of these units would actually drive a single phase induction motor of this type, but at a trade price of around £100 for the smallest of them it is obviously far too expensive for this application.

An alternative driver could be based on something similar to Thomas Scarborough's excellent *World Lamp* design (Jun '02) in which the pulse width could be made to vary with the frequency. The output waveform would be far from ideal but I see no reason why it should not work successfully, the output of smaller commercial three-phase drivers is only a very crude sine wave.

**Peter Hemsley,**  
via email

*That's interesting, Peter. I was dipping into areas unknown with the motor and was surprised at its behaviour, but assumed that torque came into it. The technique was found to be quite satisfactory for what I wanted of the tunnel.*

## TOUCH LAMPS

Dear EPE,

I am currently studying my A levels at Tring School in Hertfordshire. One of the subjects that I am studying is Design and Technology. My project this term is low voltage lighting and I have to research low voltage lights which will help a person work on a desk. One specific design idea that has caught my eye is touch lamps. I have searched for a long time on the internet and in electronic books and magazines for circuits.

Do you have a circuit which would make a touch lamp work? If you do, please could you email the circuit to me.

**Richard Lear,** via email

*There are two recent designs that might interest you, Richard, one is the Touch Switch of September '01, although it does not control a mains lamp. The other is the Time Delay Touch Switch of January '02.*

*I hope that your teacher has impressed on you that mains powered circuits are potentially lethal and that until you are suitably experienced, you should only construct them under the supervision of someone who is qualified to handle such circuits.*

*It regretted, though, that even when we have information available we can never offer to send it by email. There is always a charge made for Back Issues and photocopies, and these can only be sent by post. Prices are stated on the Back Issues page each month. Alternatively you can download recent issues for \$5 (US) from our Online website.*

## REAL TIME CLOCKS

Dear EPE,

Reader Andrew Jarvis asked in *Readout* Jan '03 about power saving and PIC clocks. When I was experimenting with your *PIC World Clock* (Aug '02), I found an old MT48T02B "timekeeper" RAM chip in my component drawer (Maplin's code DC01B). This could provide the answer to Andrew's problem. This RAM chip has an onboard clock, taking up the last eight bytes of its 2048 byte capacity. It will provide time keeping in years, months, days, hours, mins and secs in BCD format, accuracy  $\pm 1$  sec per month. The chip has onboard lithium battery back-up for approximately ten years, so should only be a maximum of two minutes out!

If Andrew were to use a transistor as a switch in the circuit's power line and held its base on with a spare PIC I/O port, a simple timing routine could turn off the whole circuit (a sort of PIC suicide switch!) – no power drain on the main battery and clock functionality carries on. A pushbutton "starter" on the transistor's base would boot the lot up again. With nearly 2K of RAM left, recordings could be made of any data wanted just before the "kill".

As is life, though, you don't get something for nothing. On-state power consumption goes up, as does the cost!

**Graham Card,** via email

*Hi again Graham, thanks for the info, which I sent on to Andrew when I received your email.*

## WELL SCORED!

Dear EPE,

Many years ago, longer than I care to think about, I transferred from what used to be *Practical Wireless* to *EPE*, buying copy number one. I pursued the hobby, building all kinds of interesting constructional projects, including the first ever *Teach In* that launched me on to my career in a branch of electronics. My hobby became my job, so somewhere along the way I am afraid I no longer did my projects or, to my regret, read the magazine.

Having lost the art of doing Project Construction now that I am retired, and needing some construction knowledge, I searched the bookstall looking for *EPE*, and I was just thrilled to find it, and that you have looked after it wonderfully well, it's just as I left it. You now have an old (old) reader back.

I am hoping that you or your contributors may be able to help. I run a quiz, and would like to make a score display that could be advanced by increments of 1 or reduced by 1 (to overcome any mistakes). I had in mind a 7-segment display possibly about 50mm high that would count to 99. Any offers?

**John Reynolds,** Peterborough. via email

*Welcome back John! I too am fascinated by electronics and many years ago had to make the choice about whether or not to make my hobby my job – well, you know the answer!*

*Your idea should not be difficult to implement, although I can't offer to design one for you, but by quoting your letter here it might inspire a reader to do so and offer it to us.*

## BABEL FISH?

Dear EPE,

I am a student and looking for a Sonar Fish Finder circuit to construct as my project. Can you help?

**Kyaw Swa Thant,**  
via email

*I replied direct saying we had not done anything like this and suggested Kyaw asked his question via our Chat Zone (entry via top link on our Home page at [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk)). Just for a bit of lightheartedness, here are extracts from the CZ offerings that resulted:*

*E-friend John Waller comments that "Fish don't make much noise, they are interested in surviving."*

*Jez Smith (what refreshment are you on Jez?!) says, "I have visions of an ickle cat in a glass box, you lower the box into the water and wait till the cat tries to catch the fish. Depending on which way the cat looks the weight shifts and you can detect that and display it."*

*While Boris wants to know, "What do Sonar Fish taste like?"*

*Kyle Curre came back on that one with "I imagine Sonar Fish tastes a tad like Infra-red Fish, with that sort of 40kHz vibration tingling on your tongue. Here's your fish-finding circuit: 1000V a.c., into the water. The fish pop to the surface, and pow! You've found them. Now take a laptop with a graphics tablet and draw it on the l.c.d."*

*With a return posted by Boris – "As a boy, one of my 'inventions' was an automatic goldfish bowl cleaning system. It was basically just two large-surface-area electrodes, one at either end of the tank with a small d.c. potential across them. Theory being that the 'dirt' will collect on the anode and keep the water clear. Of course, the first time I tested it, both the fish were instantly electrocuted. I kind of lost the will to keep fish after that . . ."*

*And before any Hitch Hiker fan asks – no, a Sonar Fish is not a relative of the Babel Fish!*

*What reader Kyaw Swa Thant appears to be looking for is a circuit for a device that transmits an ultrasonic signal (sonar) whose returned echoes are processed to show on a display screen the presence of submerged objects that might be fish. Commercial fishing boats use them.*

*Does anyone have a sensible answer to offer?!*

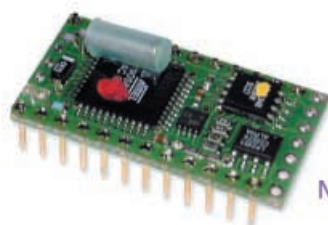
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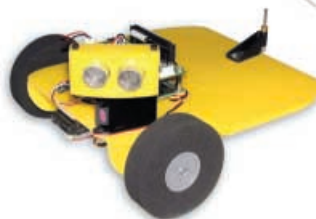
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## Earth Resistivity Logger

Nearly all the major components needed to construct the *Earth Resistivity Logger* project came from **RS Components** and can be ordered through any *bona-fide* stockists, including some of our advertisers. If a local source proves to be elusive, you can order direct (*credit card only*) from RS on ☎ **01536 444079** or through the web at [rswww.com](http://rswww.com). A postage and handling charge will be made.



The two-part case, with transparent lid, used in the prototype came from RS and is coded 507-668. However, during prolonged field surveys it was found that the specified battery "life" was short-lived and it is suggested that a larger size case be used to take a more substantial 9V battery pack.

The above-mentioned company also supplied the ICL7660 voltage inverter, code 427-304, and the RS-232 interface driver type MAX232, code 655-290. Although both devices should be readily available from components advertisers.

We only found one listing for the 24LC256 256 kilobit serial EEPROM memory chip, and that was **Farnell** (☎ **0113 263 6377** or [www.farnell.com](http://www.farnell.com)), code 300-1696.

For those readers unable to program their own PICs, a ready-programmed PIC16F876 microcontroller can be purchased from **Magenta Electronics** (☎ **01283 565435** or [www.magenta2000.co.uk](http://www.magenta2000.co.uk)) for the inclusive price of £10 each (overseas add £1 p&p). They also supplied the 2-line 16-character (per line) alphanumeric I.c.d. module.

The software is available on a 3.5in. PC-compatible disk (Earth Resistivity) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 299). It is also available for free download from the *EPE* ftp site, which is most easily accessed via the click-link option at the top of the home page when you enter the main web site at [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk). On entry to the ftp site take the path **pub/PICS/EarthRes**, downloading all files within the latter folder.

Finally, the printed circuit board is available from the *EPE PCB Service*, code 388 (see page 299).

## Intelligent Garden Lights Controller.

Apart from the PIC microcontroller and associated software, the only other component listed in the *Intelligent Garden Lights Controller* project that is likely to cause concern is the switching relay. The miniature 12V d.c. coil, p.c.b. mounting, relay used in the model has switching contacts rated at 16A 250V a.c. and was purchased from **Rapid Electronics** (☎ **01206 751166** or [www.rapidelectronics.co.uk](http://www.rapidelectronics.co.uk)), code 60-4620. Extra holes have been drilled in the circuit board to cater for other possible p.c.b. mounting types.

If you wish to use the identical low-profile pushbutton switch, this came from the above company, code 78-1520. They also supplied the miniature 5mm dia. light-dependent resistor (l.d.r.), but these should be generally available.

A pre-programmed PIC16F627 (PICAXE-18) microcontroller can be purchased (*mail order only*) from **M. P. Horsey, Electronics Dept, Radley College, Abingdon, Oxon, OX14 2HR**, for the inclusive sum of £5.90 each (overseas add £1 p&p). Make cheques payable to **Radley College**. It should be noted, however, that readers who wish to modify the BASIC program to suit their own requirements need to use the PICAXE programming software and serial lead that is only available from **Revolution Electronics, Dept EPE, 4 Old Dairy Business Centre, Melcombe Road, Bath BA2 3LR**. Tel: **01225 340563**. Web: [www.rev-ed.co.uk](http://www.rev-ed.co.uk). (This software is *not* available from *EPE*).

The BASIC and hex files are available for free download from the *EPE* ftp site. This is accessed via the main page of the *EPE* web site at [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk). At the top is a click-link saying **FTP site (downloads)**, click it then click on **PUB** and then on **PICS**, in which screen you will find the Garden Lights folder.

The software can also be obtained on a 3.5in. disk (Disk 6) from the Editorial office. There is a nominal handling charge to cover admin costs and details are given on page 299.

The printed circuit board is obtainable from the *EPE PCB Service*, code 389 (see page 299).

## Atmospherics Monitor

We have not been able to establish a supplier for the 200mm length of ferrite rod for the *Atmospherics Monitor* project. One possibility might be **J&N Factors** (☎ **01444 881965** or email [jnfactors@aol.com](mailto:jnfactors@aol.com)), who sometimes acquire ferrite rod aerials which they offer at a very reasonable price. Alternatively, readers may need to adopt the author's suggestion and glue two 100mm rods end-to-end.

The 250µA signal strength panel meter (code LB80B) and the piezo sander (code FM59P) both came from **Maplin** (☎ **0870 264 6000** or [www.maplin.co.uk](http://www.maplin.co.uk)). The LM358 dual op.amp is a very common device, but the author suggests the National Semiconductors op.amp be used here. Obviously, the "plumbing" parts will be found at any DIY superstore.

## Back-To-Basics 3 – Touch Light/Plant Watering Reminder

We do not expect readers to experience any buying difficulties when shopping for components for the two projects in this month's instalment of the *Back-To-Basics* series.

### PLEASE TAKE NOTE

#### Digital I.C. Tester

Updated software is now on our ftp site.

(Oct/Nov '02)

#### PIC Toolkit TK3

Software version V1.4, including source code, is now on our ftp site (it is the same as that on the *PIC Resources CD-ROM* – see page 270).

(Nov '01 – Supplement)



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Board cameras all with 512 x 582 pixels 8-5mm 1/3 inch sensor and composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts. They all require a power supply of between 10V and 12V DC 150mA.

47MIR size 60 x 36 x 27mm with 6 infra red LEDs (gives the same illumination as a small torch but is not visible to the human eye) £37.00 + VAT = £43.48

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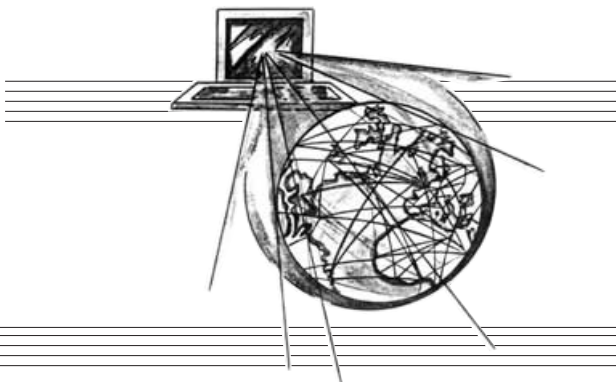
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## NET WORK

ALAN WINSTANLEY



### A Virtual Industry

**L**AST month, the popular online auction site eBay ([www.ebay.com](http://www.ebay.com) or [www.ebay.co.uk](http://www.ebay.co.uk)) was introduced for the benefit of those who are relatively new to Internet usage. Ebay is a wonderful way of selling merchandise that is too good to throw away, and there is a good feeling to be had in selling your wares knowing that it is going to a good home. This month's *Net Work* offers more practical tips to help you get the best out of online auctioneering, partly because it follows the writer's best Yorkshire tradition of not spending more brass (money) than he ever needs to!

After registering your details online with eBay, you are ready to bid or sell online, and there are many "eBayers" who run a cottage industry by trading through their web site. You can sell through them for a modest commission that eBay will deduct directly from your current account a few weeks later.

When it comes to buying, eBay provides its members with a "My eBay" web page (see screenshot) where you can store items to monitor the bidding and keep track of your purchases. The My eBay page forms the hub of all your transactions. Two buying options are provided, sometimes "Buy It Now" lets you offer to buy on the spot, but usually an auction will take place lasting for anything up to ten days. (If you're selling, it is worth using a ten-day period, also trying to ensure that two weekends are included to improve your chances of selling.)

When browsing for bargains, it pays to get a good feel for prices before getting carried away, but it's no secret that some really juicy bargains can be had, if you play your cards right. Decide on a maximum price, and maybe add 5% as a safety margin.

### Beware of Bargains

There are plenty of genuine traders, but if some items are listed very cheaply and you think there must be a catch, there almost certainly is, so you need to follow your instincts. In the case of computer software for example, it stands to reason that if an expensive product such as Adobe Photoshop 7, which retails at £530 (\$820), is being sold on eBay for only £10 "to be used for backup purposes only" then there is a good chance that a CD-writer has got in the way somewhere along the line.

Casting a keen eye over the descriptions and seller's ratings can yield some genuine bargains: brand new, shrink-wrapped Photoshop 7 for well under £300 is a bargain, especially if it can be registered with the software company. The author sourced a whole suite of genuine new Adobe software this way for less than half price.

If you really don't need the latest and greatest of computer hardware, there are plenty of used bargains available, remembering that although you have a right to expect goods to be described accurately, there will probably be no guarantee provided.

### Good Technique

There is a definite technique for buying online at the best price. Let's take Adobe Photoshop 7 again. In the past

week or two, a number of new shrinkwrapped copies came up for sale that eventually sold for about £260 to £280.

Another copy came up on a ten-day auction and users immediately started bidding for it, eager not to miss out this time around. At the time of writing the price has already reached £330 and there is still a week to go!

It is a mistake to show an interest too early, because it just stokes up the price and highlights the competitive level of interest. Instead, choose to watch the item on your "My eBay" page for a few days to see how it's going, and also search for similar items on sale at the same time.

Also remember to check an item's payment options carefully, so that you don't trap yourself into paying, for example, by Paypal if you are not a registered user. Paypal ([www.paypal.com](http://www.paypal.com)) is a very popular way of accepting credit cards online, and it is fully integrated into eBay. Check the Paypal web site closely for details of the registration process, which can take up to 30 days to complete, as it requires verification of a nominal test entry on your credit card statement.

### Snipe a Bargain

As mentioned last month, eBay uses a system it calls proxy bidding, so you can enter a maximum bid in the knowledge that you could actually win for much less, if no-one else bids. Bidding is raised in fixed increments (say £2 or £5). By timing your maximum bid correctly, you could enter a value that you are sure no-one else will want to beat (say £350 for Photoshop 7); you then become the highest bidder, *but your actual price will only be one increment above the current price* (say £285).

In this way, then if no-one else bids, you can win an auction by pricing everyone else out of the market, because they would have to exceed your maximum bid (in which case, they're welcome to it). However, having forced up the price, someone could still outbid you and win by as little as one penny. It can be an exciting if not nerve-wracking experience, watching the bids suddenly mount up at the last moment.

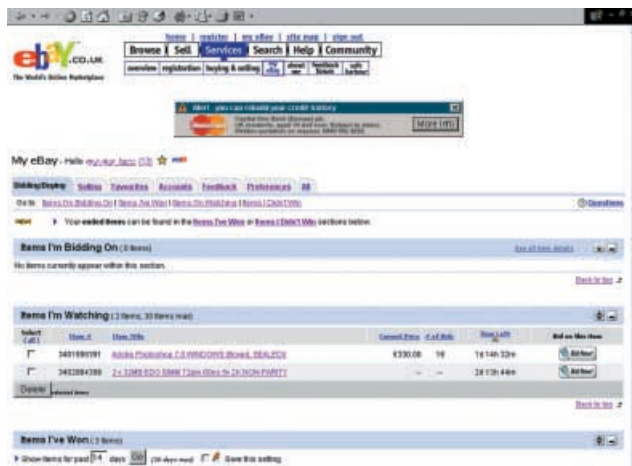
### Seconds Out

This is a crucial aspect of bidding: an "eBay-savvy" user will only bid in the closing moments of an auction. If you are struggling on ordinary dial-up Internet access, then you have no hope of refreshing your screen in time to fetch the latest bids, so you cannot usually enter a higher bid in the closing seconds of an auction.

On several occasions the writer has hoped to win a particular auction, only to be outbid in the last ten seconds or less, and with the clock ticking by, the auction has ended (they are literally timed to the second) before another bid could be entered. This last-minute winning bid is called *sniping* and it can be very aggravating!

Next month: How to become an eBay auction "sniper", and how you can suddenly start to win one auction after another by entering a trumping bid with just three seconds left before the auction closes!

You can email me at [alan@epemag.demon.co.uk](mailto:alan@epemag.demon.co.uk).



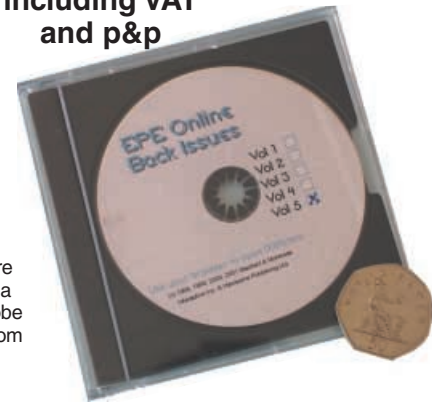
The configurable "My eBay" page forms the hub of online bidding, allowing users to monitor auctions and bids.

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# BACK TO BASICS



**BART TREPAK**

**Part Three**

*Illustrating how useful circuits can be designed simply using transistors.*

## TOUCH LIGHT

**T**HERE are many places around the house where a small light would be useful but running a mains cable to the location is impractical. Corners of dark cupboards, over the telephone to light a note pad, by the front door to help find the keyhole at night, are just some of the applications which come to mind.

None of these require very much light and high brightness light emitting diodes (l.e.d.s) can not only provide the illumination needed, but can also be readily fitted with a time delay circuit so that they switch off automatically, so saving battery power. The circuit described here offers such a solution. It is shown in Fig.18.

To ensure that the circuit switches off after use and prevent having to change the battery too often, a timing circuit is required. For this a monostable has one stable state, in this case the *off* state. When triggered into its *on* state, it will remain in that state for a preset period before switching off again.

Some circuits of this type use two transistors (*npn* or *pnp* types) configured so that in the stable state one transistor is on while the other remains off. Following a trigger pulse, both transistors change state. A disadvantage of this circuit is that during the off state, one of the transistors is always turned on, and so consuming power.

An alternative configuration is used here in which all transistors remain off when the circuit is in its stable state, so consuming virtually no current.

### TOUCH CIRCUIT

In the circuit diagram shown in Fig.18, transistors TR2 and TR3 form the monostable circuit, with capacitor C1 and resistor R2 determining the time for which the transistors remain on once the circuit has been triggered.

This occurs when finger contact is made with touch pad TP1. The 50Hz mains "hum" normally present in all households will be induced into the circuit through the finger, causing transistor TR1 to turn on. This provides base current to TR3, turning it on, together with the l.e.d. (D2), whose current is buffered by resistor R3.

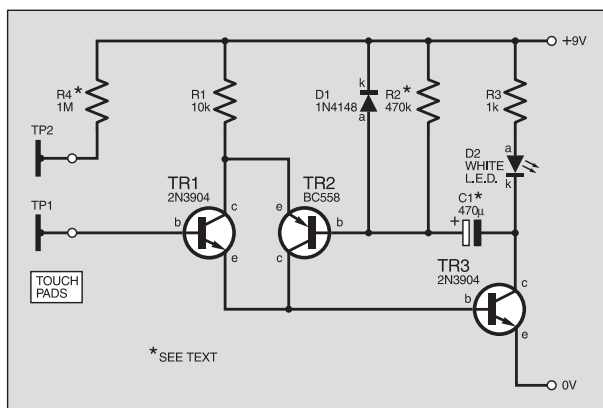


Fig.18. Circuit diagram for a three-transistor Touch Light.

When the collector of TR3 goes low, a negative-going pulse is generated across capacitor C1, causing TR2 to turn on and provide more current to the base of TR3. When the contact with TP1 is broken, TR1 ceases to conduct, but TR3's base continues to be held on via TR2. However, C1 starts to charge via resistor R2. Eventually, its charge rises to within less than 0.6V of the positive power supply, turning off TR2 and thus TR3 and the l.e.d. as well. Diode

D1 inhibits any positive-going pulse generated across C1 when TR2 switches off.

With the component values shown, the l.e.d. will remain on for about three minutes.

### TOUCH-DOWN

It is worth noting that touch pad TP2 may be needed if the 50Hz mains "hum" introduced by finger contact with TP1 is not strong enough, or non-existent, as in a garden shed for example. Making finger contact between TP1 and TP2 causes a small current to flow from the positive line, though the finger and into the base of TR1. It is advisable to insert resistor R4 between TP2 and the positive line to prevent damage to TR1 should the two pads be shorted accidentally by an object with a low resistance.

If the unit is found to be too sensitive, a high value resistor of about 10MΩ can be connected from the base of TR1 to the battery negative. This will prevent the circuit from switching on inadvertently, especially in areas where the mains field is high.

## COMPONENTS

### Resistors

R1	10k
R2	470k (see text)
R3	1k
R4	1M (see text)

See **SHOP TALK** page

### Capacitor

C1	470μ axial elect. 16V (see text)
----	----------------------------------

### Semiconductors

D1	1N4148 signal diode
D2	white l.e.d., high brightness (see text)
TR1, TR3	2N3904 npn transistor (2 off)
TR2	BC558 pnp transistor

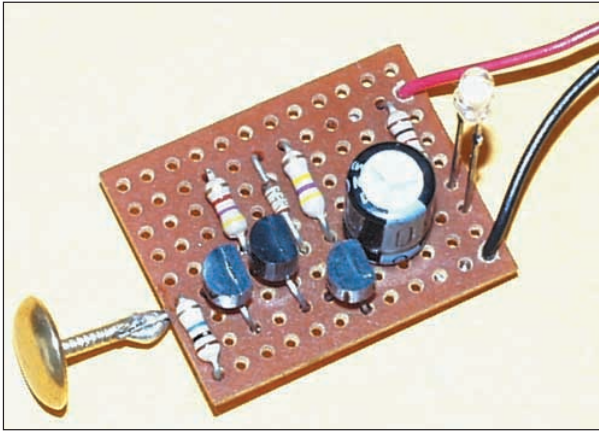
### Miscellaneous

Stripboard, 8 strips x 12 holes; touch pad(s) (see text); case to suit; connecting wire; 9V battery, with holder and clips; solder, etc.

Approx. Cost Guidance Only

**£4**

excl. case and battery



Prototype Touch Light circuit board. The additional resistor seen bottom left is not required in this circuit.

## CONSTRUCTION

The circuit is built on a small piece of stripboard having 12 holes by 8 strips, as shown in Fig.19. Only two track cuts need to be made and no wire links are required. Apart from the resistors, all other components must be inserted the correct way round.

Power to the circuit should be supplied by a 9V battery. As the stand-by current is extremely low (basically the leakage current of the transistors), the expected life should be almost the shelf life of the battery, depending of course on how often it is switched on. Consequently, an on/off switch is not required.

The finished unit should be mounted in an insulated plastic box of a size suitable

for the battery and circuit board. The touch contact(s) can be made from any piece of metal such as a bolt or nail, but a drawing pin pushed through a suitable hole in the box and connected to the board via a short length of wire provides a neater, more attractive finish.

## L.E.D. CONSIDERATIONS

When on, the total current is 6mA with the l.e.d. accounting for about 5.8mA. White l.e.d.s exhibit a forward voltage drop of around 4V, so two could be used in series to provide more light. Resistor R3 would then need to be reduced to 470 $\Omega$  to maintain the l.e.d. current at around 5mA.

The brightness of the l.e.d.(s) can be increased by reducing the value of R3 to

increase the current flow. Do not allow the current to be greater than that permitted by the l.e.d., which should be stated in its data sheet and supplier's catalogue. There appears to be little apparent increase in brightness beyond about 10mA.

Data sheets normally quote an l.e.d. viewing angle and this describes the "off axis" brightness of the device. Unlike the filament in a light bulb, an l.e.d. chip emits light only from its surface, rather than all around, so the light comes mainly from the front of the device. This is modified to some extent by the plastic package and l.e.d.s are available with a more or less focused light beam. Depending on the use, a wider angled light pattern may be preferred.

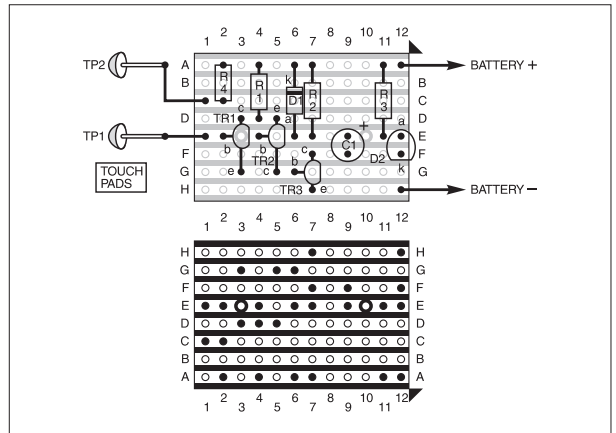


Fig.19. Stripboard component layout and underside copper tracks showing two cuts in strip E.

# PLANT WATERING REMINDER

**H**OUSE plants in general often have a pretty hard time of it compared to their garden bound cousins, which seem to get more than their fair share of watering, even if their owner forgets, thanks to the British weather. With so many other things to think about, the first reminder that many people get to water their plants is when it is noticed that one or two are wilting or the leaves are turning brown and dropping off!

Modern central heating also ensures that the soil in pots dries out much faster, making regular watering more important, so that a little electronic help in remembering to do so should be most welcome.

## CIRCUIT DIAGRAM

The circuit suggested here, and shown in Fig.20, drives a piezo sounder, WD1, to provide a timely warning that the soil in the plant pot is almost dry.

Hopefully, the plants will be watered regularly so the alarm will remain off but it may become active at any time and it is unlikely that the plants will be watered immediately as the owner may be out. It may therefore continue to sound all day before the plants are watered. To avoid having to replace the battery too often, it is

important to ensure that the current drain in either condition is as low as possible.

To minimise the current drain during the alarm condition, a complementary astable circuit built around transistors TR2 and TR3 is used. Its operation is beyond the scope of this article, but it oscillates with a frequency determined by resistor R2 and capacitor C1. With the component values given the frequency will be about 2kHz, producing a fairly loud sound from piezo sounder WD1. This device has a very high impedance and so a load resistor, R3, is provided for TR3.

Since both transistors switch on and off together and remain off for a relatively long period (dependant on the value of R2) compared to the time when they are on, the average current drawn from the battery is very low, at about 1mA.

The output consists of short positive

going pulses which turn on the piezo sounder WD1. The operation of the oscillator is controlled by TR1. When this transistor is on, the base of TR2 is held low and the circuit cannot oscillate.

The circuit relies on sensing the resistance of the soil between two metal probes which are inserted into the pot close to the plant. Completely dry soil will have a relatively high resistance but this will fall as the moisture content is increased.

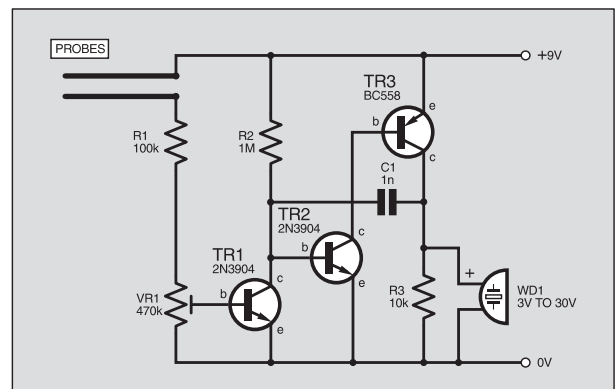


Fig.20. Circuit diagram for the Plant Watering Reminder.



Completed Plant Watering Reminder circuit board. The probes have been covered with plastic sleeving, except their tips.

The series resistance of the probes, resistor R1 and potentiometer VR1 form a potential divider across the supply. With the soil moist, the resistance of VR1 can be adjusted so that the voltage at the base of TR1 is at 0.6V, ensuring that this transistor is switched on and so disabling the oscillator.

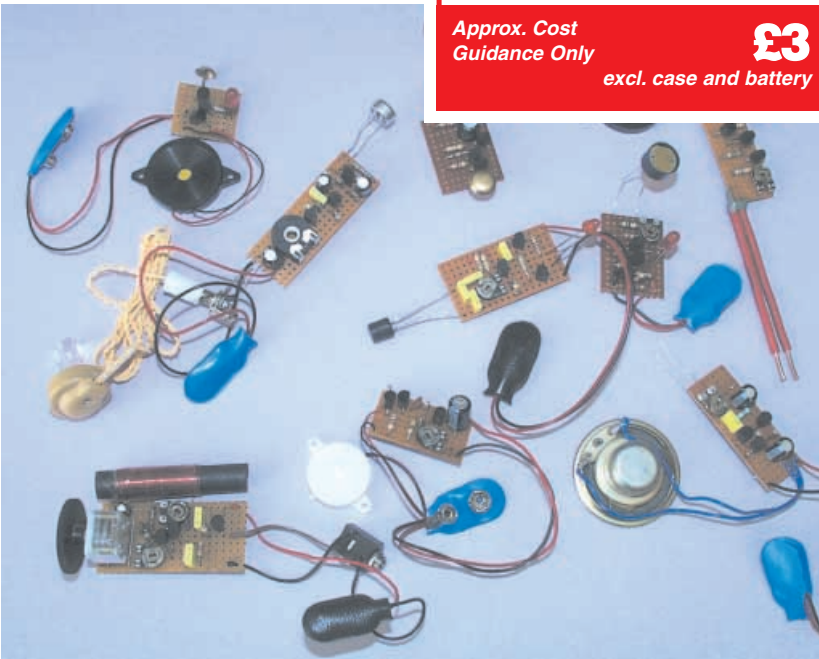
As the soil dries out, the base-emitter voltage of TR1 falls to a point at which it switches off sufficiently to allow the oscillator to function, producing an audible warning.

As described earlier, this circuit produces short output pulses and therefore draws only a small current when it is oscillating (about 1mA).

In the stand-by condition when the oscillator is switched off, the current drain on the battery is only 10 $\mu$ A, so the battery should last a long time.

## CONSTRUCTION

The circuit is built on a piece of strip-board having 7 strips  $\times$  15 holes, as shown in Fig.21. Only one strip cut is required and there are no link wires. Care should be taken to ensure that the transistors and the sounder are connected the correct way around.



Some of the simple transistor-based circuit assemblies described in this series.

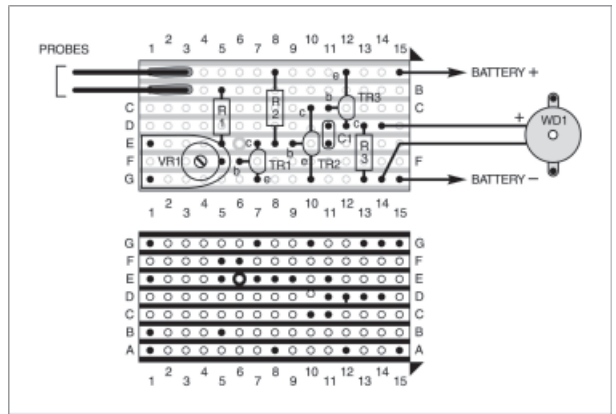


Fig.21. Plant Watering Reminder component layout; only one copper track break is needed.

## COMPONENTS

### Resistors

R1	100k
R2	1M
R3	10k

### Potentiometer

VR1	470k min. skeleton preset.
-----	----------------------------

### Capacitor

C1	1n ceramic disc, 2.5mm pitch
----	------------------------------

### Semiconductors

TR1, TR2	2N3904 <i>n</i> pn transistor (2 off)
TR3	BC558 <i>p</i> np transistor

### Miscellaneous

WD1	3V to 30V piezo sounder
-----	-------------------------

Stripboard, 7 strips  $\times$  15 holes; PP3 battery and clip; stout metal probes (see text) (2 off); case to suit, connecting wire; 9V battery, with holder and clips; solder, etc.

Approx. Cost  
Guidance Only

£3

excl. case and battery

See  
SHOP  
TALK  
page

The probes consist of two stiff metal wires the length of which is not particularly important and will depend to a large extent on the size of the pot into which the unit is placed. Copper is perhaps the easiest wire to get hold of (and to solder).

In the prototype, two 10cm lengths of 2.5mm diameter rigid wire of the type used in house wiring were used. These were soldered directly to the tracks at the positions shown, the wire being too thick to pass through the holes in the board.

Since these are liable to break off if the probes are pushed into hard earth, it is probably best to solder the wires directly to the copper tracks straddling several holes. This may then be strengthened by covering the joints and an adjacent area of the board with epoxy glue. Alternatively, the wires may be mounted a few millimetres apart on an insulating surface, such as the plastic box in which the unit is to be placed, and connected to the board by flying leads.

## SOUNDLESS ALARM

When completed, place the probes in moist soil close to the roots of the plant. Set VR1's wiper to a fully anti-clockwise position, and then adjust it until the circuit just fails to oscillate. Should the alarm sound as the soil dries out but it is still judged to be too moist to require watering, VR1 should be turned further clockwise.

In some situations, an audible alarm may not be desirable, in which case the sounder can be omitted, and an l.e.d. plus ballast resistor of about 470 $\Omega$  can be wired in place of R3, with the anode (a) connected to transistor TR3's collector, and the other side of the 470 $\Omega$  resistor on the 0V line. Omit R3 itself. Do not use the l.e.d. without the ballast resistor as the current through it cannot be guaranteed to be within its limits, even though the current is pulsed.

The sounder and l.e.d. may both be fitted, although this will result in a slightly increased current consumption and a slightly reduced sound output, but should still be adequate for most situations.

## NEXT MONTH

In the next issue we present a Live Wire Detector that safely locates the presence of mains electrical circuits, plus a simple MW Radio.



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If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours. Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best *IU* submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

**T**HE simple probe circuit of Fig.1 was designed for use in tracing 6V or 12V vehicle wiring. Basic probes have a crocodile clip which is connected to ground (chassis) while a single bulb or l.e.d. illuminates when the probe makes a positive connection. If the indicator does not light up, then the probe is assumed to be making a ground connection.

This circuit is intended to remove the ambiguity of that assumption by providing a clear indication of the three following states:

- 1 – A red l.e.d. will illuminate to indicate a "positive" connection.
- 2 – A green l.e.d. will illuminate to indicate a "ground" connection.
- 3 – A yellow l.e.d. will illuminate to indicate "no connection" (floating condition).

With no connection to the probe (i.e. floating input), l.e.d. D3 (yellow) will be switched on via NAND gate IC1b which will have a "high" applied to each of its inputs (pins 5 and 6), making the gate's output go "low".

Should the probe make contact with 0V (ground) then transistor TR1 will be switched off which drives the output of IC1a low, thus illuminating l.e.d. D2 (green). Simultaneously IC1a will apply a low to pin 5 of gate IC1b, causing its output to go high, therefore extinguishing yellow l.e.d. D3.

When a positive input is applied to the probe, TR2 will switch off causing IC1c output to go high. This output is inverted by IC1d and switches on D4 (red). At the same time, the output of IC1d is also taken to pin 6 of IC1b, which then extinguishes the yellow l.e.d. D3.

## Three-State Vehicle Probe – A Positive Response

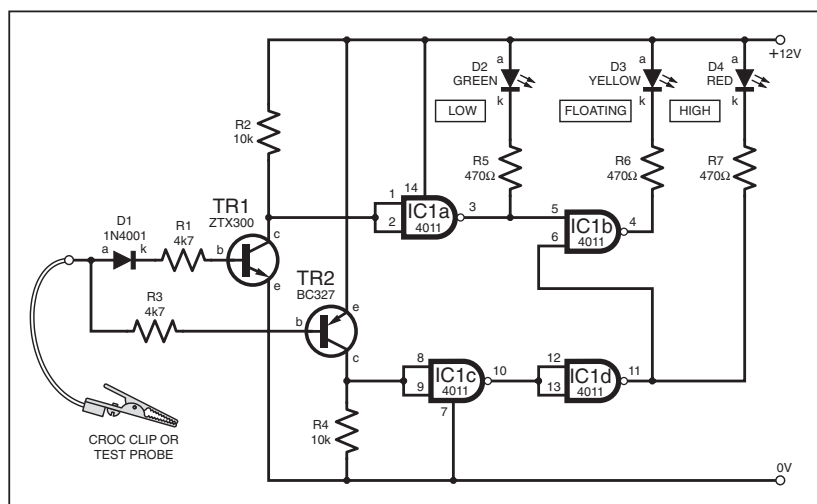


Fig.1. Circuit diagram for the Three-State Vehicle Probe.

A supply for the circuit was obtained from the vehicle's cigar lighter socket, or you could use a fused 12V lead to clip onto the

car battery terminals, placing the fuse as near as possible to the battery's positive pole.

T. J. Heaney, Northallerton

## PCB Drill Controller – A Bit More Action

**A**FTER buying a small low voltage drill for working on printed circuit boards, it was noticed that the drill motor would stall if the input voltage was less than 15V. This voltage resulted in a higher power but also a higher

drill speed which increased the heat and wear on the drill bit, rapidly making it blunt.

The circuit diagram shown in Fig.2 uses pulse control to decrease the drill speed while maintaining the output power. IC1a is one half of a 556 timer and is set in astable mode to provide a base frequency of approximately 150Hz. This is fed into IC1b which triggers the monostable, set by Speed potentiometer VR1 to have a period of between 0.1ms to 10ms.

The duration of the monostable determines the period that the drill motor has the full 15V potential across it, and hence the speed of the drill which is lowest when the time period is 0.1ms. The output of IC1b is connected to the base of transistor TR1 which is a high current (3A) power transistor that controls the load. It is protected from inductive voltage spikes by diode D1. The circuit proved to be very effective and can be powered from an existing 12V to 15V d.c. drill power supply unit.

Daniel Salt,  
Hunstanton, Norfolk

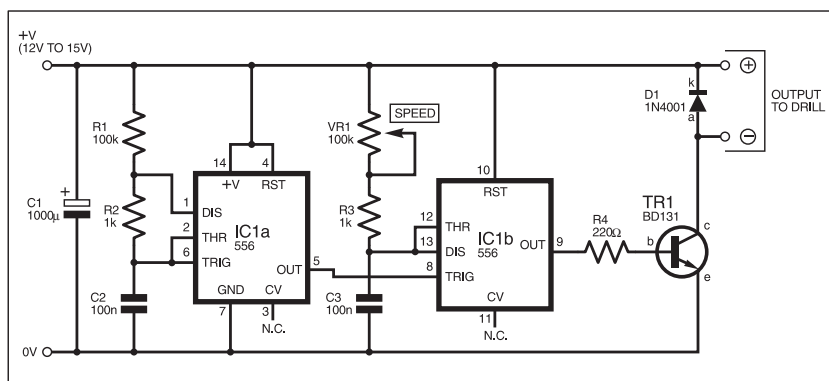


Fig.2. Circuit diagram for a low-voltage PCB Drill Controller.

## StyloQIC – To The Point

**T**HE circuit diagram shown in Fig.3 was inspired by the *EPE StyloPIC* design (July '02 issue) and is a minimalist “Stylophone” that is “QIC” to build!

It uses just 14 components to play two octaves. In addition, it sports an optional tremolo or frequency modulation feature. It uses virtually zero current on standby, and therefore requires no on-off switch.

The oscillator, based upon IC1a, may be likened to a conventional RC Schmitt oscillator, except that R is replaced with an inductor. The inductor works by opposing electrical pulses (inductive reactance), thus impeding the charge and discharge of capacitor C1. If a pair of headphones or a miniature speaker (LS1) is used for the inductor, a good audible tone is heard.

Resistor R1 limits back e.m.f. across the gate's inputs and output to help protect IC1a. Preset potentiometers (wired as variable resistors) VR1 to VR8 are all one kilohm (1k) types that adjust the pitch of eight notes individually. If an additional 1kilohm preset is inserted at IC1a output using push-to-make pushbutton switch S1 wired in parallel, the pushbutton will provide one additional octave.

The circuit diagram of Fig.4 is an add-on Tremolo function. This RC oscillator

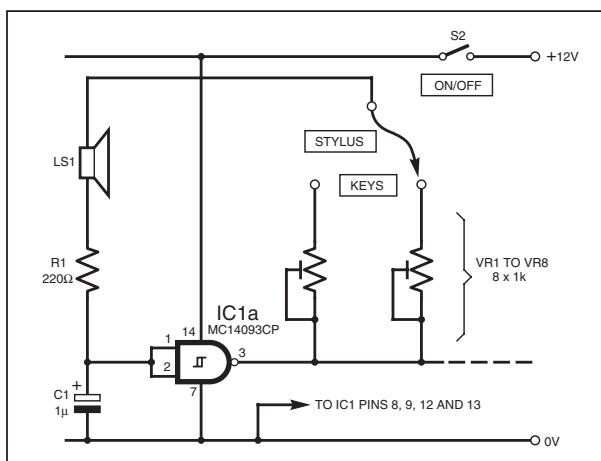


Fig.3. Circuit diagram for the basic StyloQIC.

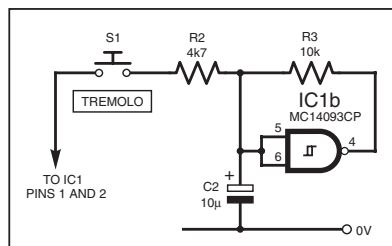


Fig.4. Adding a Tremolo function to the StyloQIC circuit.

modulates the frequency of IC1a as the voltage across capacitor C2 rises and falls. Since this rapidly raises and lowers the set frequency of each note, it does not change the fundamental frequency when applied.

The tremolo unit draws 1mA, and may therefore necessitate an on-off switch for the StyloQIC if used.

The widely available 4093 quad NAND Schmitt i.c. was used but a 40106 hex Schmitt inverter may also be used to good effect, in which case the value of capacitor C1 needs to be halved.

*Rev. Thomas Scarborough,  
Fresnaye,  
South Africa.*

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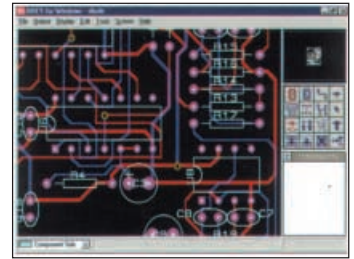


Logic Probe testing

*Electronic Projects* is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK schematic capture, circuit simulation and p.c.b. design software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

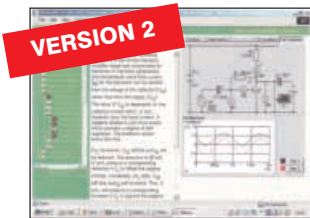
## ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots, etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

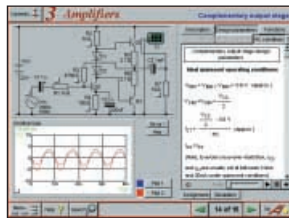
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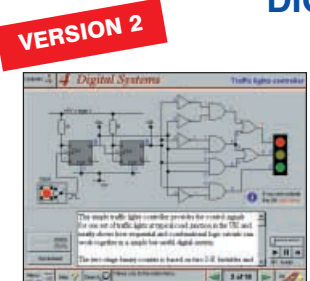


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Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

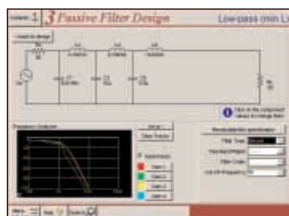
## DIGITAL ELECTRONICS V2.0



Virtual laboratory – Traffic Lights

*Digital Electronics* builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen. Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

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Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
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# PICmicro TUTORIALS AND PROGRAMMING

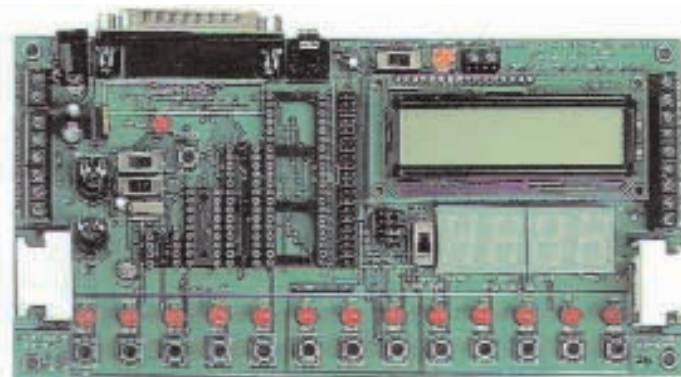
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- Comprehensive instruction through 39 tutorial sections
- Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator
- Tests, exercises and projects covering a wide range of PICmicro MCU applications
- Includes MPLAB assembler
- Visual representation of a PICmicro showing architecture and functions
- Expert system for code entry helps first time users
- Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.)
- Imports MPASM files.



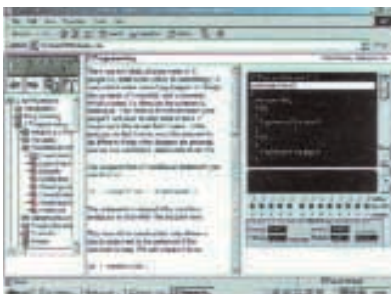
Virtual PICmicro

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The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

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- Complete course in C as well as C programming for PICmicro microcontrollers
- Highly interactive course
- Virtual C PICmicro improves understanding
- Includes a C compiler for a wide range of PICmicro devices
- Includes full Integrated Development Environment
- Includes MPLAB software
- Compatible with most PICmicro programmers
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Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

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Burglar Alarm Simulation

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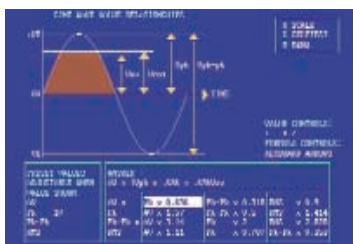
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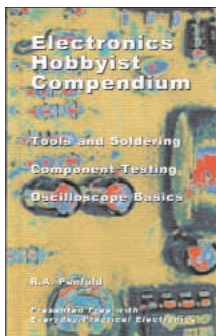
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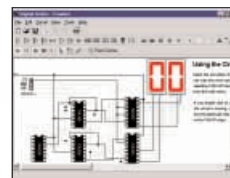


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# EARTH RESISTIVITY LOGGER

JOHN BECKER

Part One

*Help your local archaeological society to locate and reveal the hidden mysteries of our ancestors.*

**J**ANUARY and February 1997 saw the publication in *EPE* of Robert Beck's *Earth Resistivity Meter*, an electronic tool to assist amateur archaeological societies "see beneath the soil" in their search for ruins and other hidden features.

The design presented here is based upon the same concept as used in Robert's circuit, but it has been considerably simplified in terms of the components count and their ready-availability. Significantly, it has also been put under the command of a PIC microcontroller and provided with data logging facilities. The principal features of this design are outlined in Table 1.

## DOWN TO EARTH

Before going any further, though, the author wishes to "put his cards on the survey grid". He is not an archaeologist and has approached this design purely as an electronic problem to be solved – transmit a signal, retrieve it at a distance and store it for later analysis.

Along the path to this end, he has researched a fair bit, chatted with a local archaeological society and with *EPE* readers who have knowledge in this field. Most importantly, Nick Tile, *EPE* reader and friend of the author, has spent several months successfully using the prototype for active archaeological survey work. More on this in Part 2. Further reference to Nick's surveying will be made during this article.

A list of useful references is quoted at the end of Part 2, to which readers are referred for more information on surveying techniques. The main reference source used by the author has been Anthony Clark's *Seeing Beneath the Soil*.

## BASIC PRINCIPLES

For the sake of readers who have not yet been enticed into joining their local archaeological society in search of knowledge about our ancestors and how they lived, it is appropriate to outline how electronics can help us see subterranean features without ever touching a spade or trowel.

When two conductors are placed in moist soil with a d.c. voltage source

connected across them, current will flow between them, just as it does through an ordinary resistor.

The amount of current that flows depends on how much resistance the soil interposes between the two electrodes. The value depends on several factors, the soil's water content and chemical make-up (i.e. the impurities the water contains), and the presence (or absence) of non-conductive objects. The relationship is complex, and will not be discussed in detail here, although some experiments which should give an insight into it are suggested in the text file supplied with the software. It is discussed more fully by Anthony Clark in his book.

The current flow through soil is also complicated by the fact that it is not flowing in a straight line, as it does (in effect) through an ordinary resistor. The current can simultaneously flow through a multitude of paths, not only horizontally, but three-dimensionally, as illustrated in Fig.1. It also radiates outwards beyond the

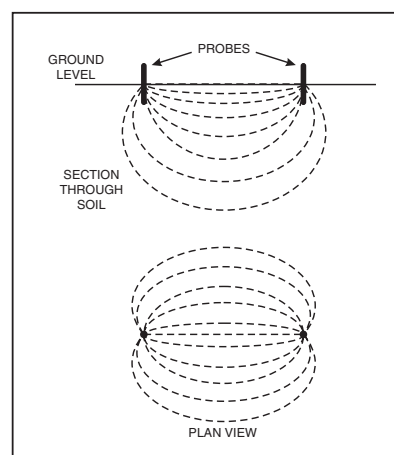
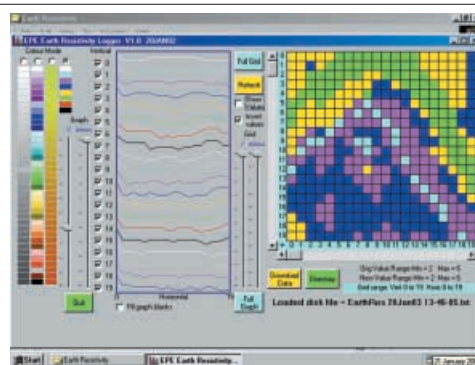


Fig.1. Current paths set up by probe array.

main field, as you will see presently from Fig.2.

The overall current flow between the probes is thus not just governed by the resistance of one direct horizontal path, but by the total resistance of innumerable paths effectively in parallel within a given volume of soil, and each experiencing different values of resistance. Despite the complexity, though, as far as the reading on a current meter is concerned, the answer is a single value, and from it an assessment of the soil's relative density can be made.



Prototype Earth Resistivity Logger, housed in a plastic case with transparent lid.

What is being looked for in an electronic survey is reliably monitored variations in readings across a site, the pattern of which indicates where different sub-soil features exist.

## UNIFORMITY PROBLEM

A problem arises, however, in that not only does the soil have resistance, but it also has capacitance and additionally exhibits various electrolysis effects as the d.c. current continues to flow, and most significantly, a polarization process takes place, resulting in progressively changing values on the meter.

To be able to take meaningful readings it is necessary to counteract the polarization effect. This can be done by passing an alternating current through the soil instead of a direct one. With each of the a.c. current's phases, the polarizing effects of the preceding phase are reversed, thus causing a more consistent current flow to occur in both directions.

Whilst the soil's electrolysis process will not be reversed, its effect is likely to be so minute in relation to the polarization effect, that it can be ignored during the relatively brief time during which current flow readings are taken.

The capacitance effects are also largely overcome by using an alternating current at a suitable frequency.

## PROBING FREQUENCY

The question then arises: at what frequency should the current direction be repeatedly reversed? Too high a frequency will cause the soil's capacitance effects to "mop-up" and attenuate the alternating signal's amplitude. Too low a frequency will again cause variation in the monitored readings, albeit smaller than would occur through using a d.c. signal.

It appears that the optimum rate at which the signal phases must be changed has been established at around 137Hz (Anthony Clark quotes 137.5Hz but also says that 67Hz is used in some equipment). These frequencies assist in not only the elimination of the polarizing effects, but also in reducing the affect of other alternating electrical fields which might be present in the site being surveyed, such as a 50Hz mains frequency, for instance.

**TABLE 1. WHAT IT DOES**

### *The PIC microcontroller performs the following functions:*

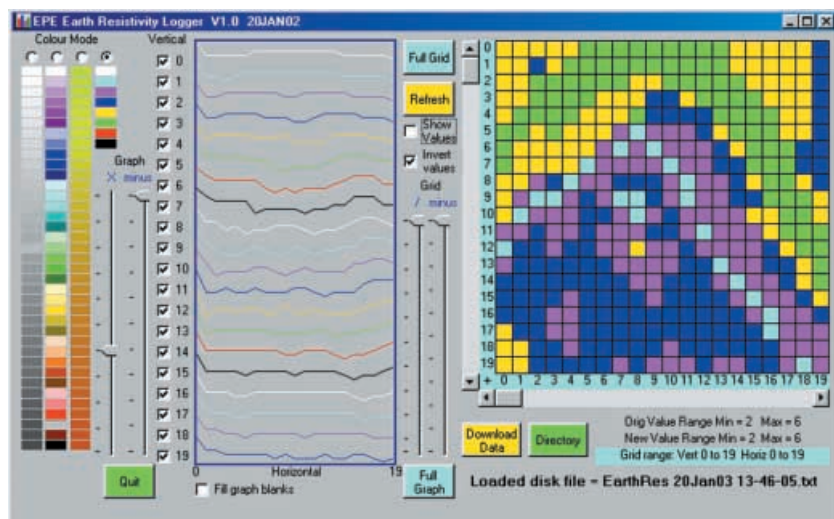
- Generates 137Hz square wave ground-penetrating transmission signal
- Converts the received and amplified analogue signal to a 10-bit digital value
- Stores each converted value to user-specified non-volatile (EEPROM) memory address representing specific site plotting coordinates
- Continually displays immediate real-time data and coordinates on alphanumeric liquid crystal display (l.c.d.)
- On request, outputs stored data via serial link to Windows 95/98/ME PC for storage to disk and subsequent analysis

### *Other features of the logger include:*

- Switchable output resistance to vary transmission current
- Switchable amplifier gain, x1, x10, x100
- Pushswitch selection of survey site row and column coordinates allocation in memory
- Memory capacity for 16384 10-bit samples, representing a survey site grid of 128 x 128 squares
- Data storage action under complete user control
- Data locations may be overwritten with fresh data if required
- Sampled data stays in memory indefinitely, even after power switch-off
- Recall of last used survey coordinate when next switched on, allowing survey to be spread over several days or weeks
- Individually stepped push-button recall and display of recorded samples and their coordinates
- Total clearance of memory to zero value upon request, with security feature to help prevent erroneous use
- Operable from any d.c. supply between about 9V and 15V, consuming about 25mA. It is equally suited for use with a 9V PP9-size battery (rechargeable types are available), or a 12V car battery (see later)

### *Software features for the downloaded memory samples include:*

- Program written in Visual Basic 6 (VB6)
- Disk storage under unique dated and timed file name
- Graphical display of data on PC screen as waveform graphs and value-related coloured or grey-scale grid squares
- Four screen slider controls allow data to be processed for best visual contrast to aid analysis
- Facility to invert data values for viewing as "valleys" or "peaks"
- Main screen display as 20 x 20 samples block, with vertical and horizontal panning across full 128 x 128 grid
- Secondary screen displays of separate grid or graph data for full 128 x 128 samples block
- Zoom facility for closer examination of separate graph and grid data
- Reloading of previous survey files via dedicated file selection screen
- Downloaded files stored in format suited for analysis and graphical display via Microsoft Excel (found on most PCs)
- Data may be downloaded to PC as often as required without disrupting its existing on-board storage (allowing on-going visual display of site progress across long periods)
- Suited to survey monitoring using any of the standard probing techniques (Wenner, Schlumberger, Twin-Probe, etc).



Typical example of one of the three analysis screens used by the Earth Resistivity Logger's PC software. The other two show full-screen displays of grid or graph data for a 128 x 128 samples survey site, with zoom facilities.

EPE contributor Aubrey Scoon has researched into this latter aspect and has reported the presence of many other frequencies in some locations he has examined, some emanating from a nearby "supercomputer" in one instance.

The frequencies of 67Hz and 137Hz (the latter is used in this Logger), are not a multiple of 50Hz, nor of the 60Hz cycle used in some countries, such as the USA. Thus, by performing rectification or sampling that is synchronised with the transmission signal, the effects of these extraneous fields can be reduced. They are also minimised by the use of a differential amplifier, which will be discussed presently.

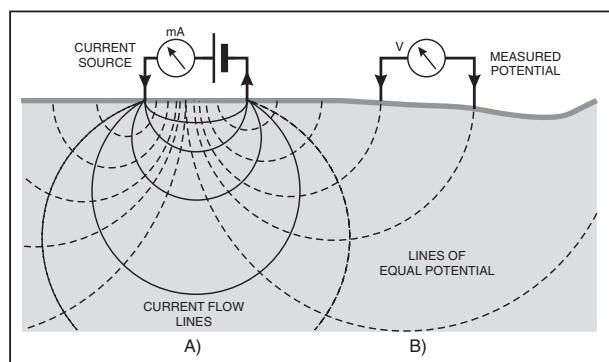
It is worth pointing out, however, that in the suburban garden where the author's trials with this Logger were performed in conjunction with an oscilloscope, residual 50Hz mains currents were not evident.

## MULTIPLE PROBES

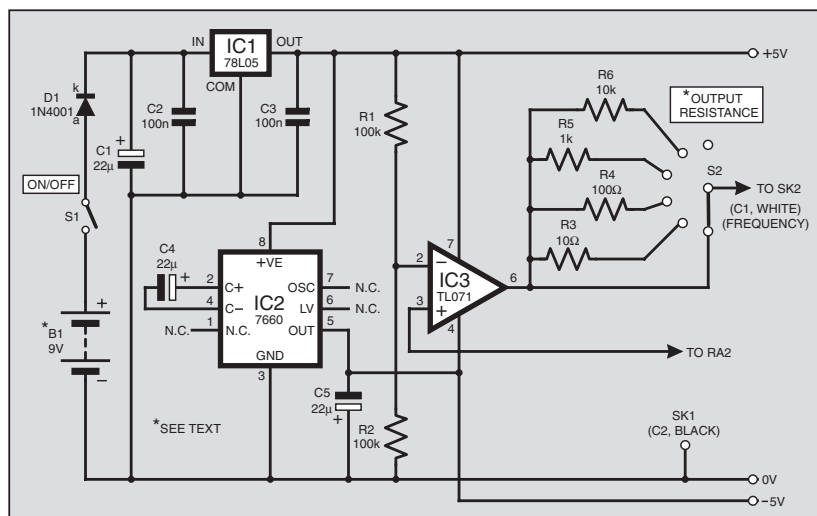
The discussion so far has been in relation to the current flowing between two probes in series with a meter. Over the many years that geophysicists have been

Most of the favoured ones all use four probes – two for transmission (TX), and two for reception (RX). The righthand section of Fig.2 shows one way in which the second pair of probes can be used. Anthony Clark says that there are also some techniques that use five probes – with push-pull TX across two and the fifth becoming a grounded reference perhaps?

There are several ways in which four probes are used in relation to each other, and each with its own merits. Their use is outlined later, but no quality judgement is offered here on their appropriateness to



It is not even necessary to use special probes, any metal object that does not corrode and can be inserted into the soil with





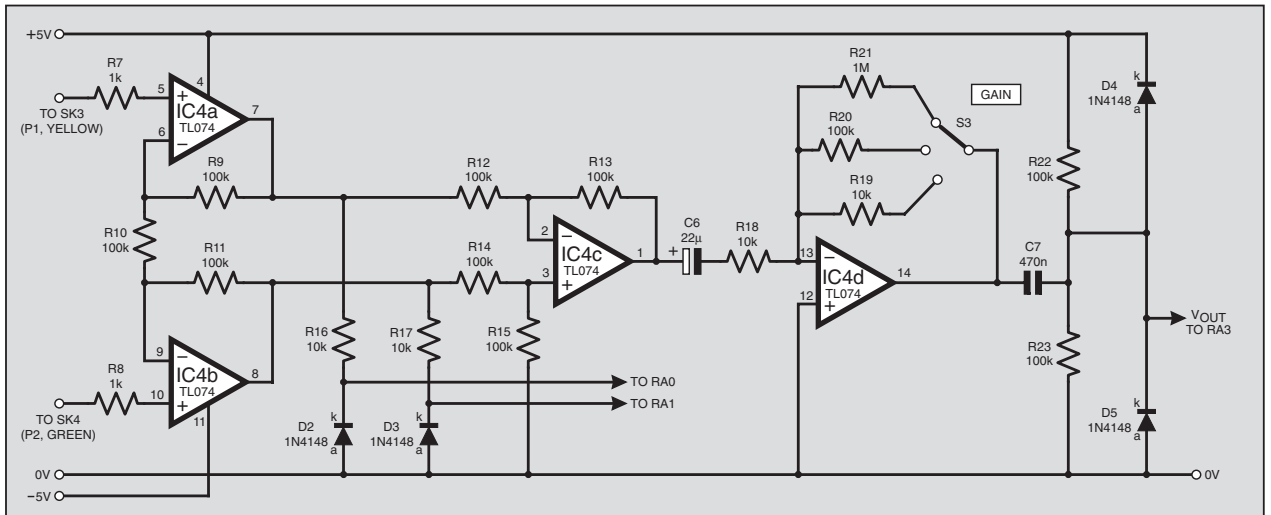


Fig.4. Differential amplifier that receives, amplifies and conditions the RX probes signal prior to sending to the ADC input of the PIC microcontroller.

the author and Nick Tile were carried out via the direct TX path (Nick says he has not found the switchable resistance facility to be useful). In this role, the signal amplitude across the TX probes is picked up by the RX probes simply as an alternating signal whose amplitude varies according to the soil density it has to pass through.

## RECEIVING CIRCUIT

The receiving circuit is shown in Fig.4. The twin RX probes and their received d.c. coupled signals are connected via buffering resistors R7 and R8 to the respective inputs of the differential amplifier, formed initially around op.amps IC4a and IC4b and having a gain of three. The outputs from these op.amps are summed, still as d.c. signals, by op.amp IC4c, which provides unity gain.

The resulting signal represents the difference between the two input signal levels. It is now a.c. coupled via capacitor

C6 to the amplifying stage around IC4d. Here the gain can be switched by S3 between  $\times 1$ ,  $\times 10$  and  $\times 100$ . In the prototype's garden tests, the  $\times 1$  gain was satisfactory across the maximum probe separation distance that the dense garden flower beds would allow (11 metres)! Nick says he prefers the  $\times 10$  setting.

At this stage the signal is swinging above and below 0V. It has to be shifted so that it only swings between 0V and +5V at the maximum extremes, to suit the PIC microcontroller's limits. This is achieved by a.c. coupling the signal via capacitor C7 to the level-shifting potential divider formed by resistors R22 and R23. Diodes D4 and D5 limit the maximum voltage swing then fed to the PIC, preventing it from swinging above or below the PIC's limits of acceptance.

It will be seen that two additional signal paths are provided from the output of IC4a/b and consist of resistors R16 and

R17 plus diodes D2 and D3. These are not part of the required analogue processing circuit but were included for use during software development. Their function will be described presently.

## CONTROLLER CIRCUIT

The PIC-controlled processing circuit is shown in Fig.5. At its heart is a PIC16F876 microcontroller, IC5, manufactured by Microchip. It is run at 3.6864MHz, as set by crystal X1. The frequency may seem unusual, but crystals tuned to it are standard products. Its choice provides greater accuracy of the baud rate at which the logged data is output to the computer.

The software-generated 137Hz square wave pulse train is output via pin RA2, and fed to the TX op.amp IC3 in Fig.3.

Pin RA3 is the pin to which the level-shifted signal output from IC4d is input. The pin is configured by the software as an analogue-to-digital converter (ADC).

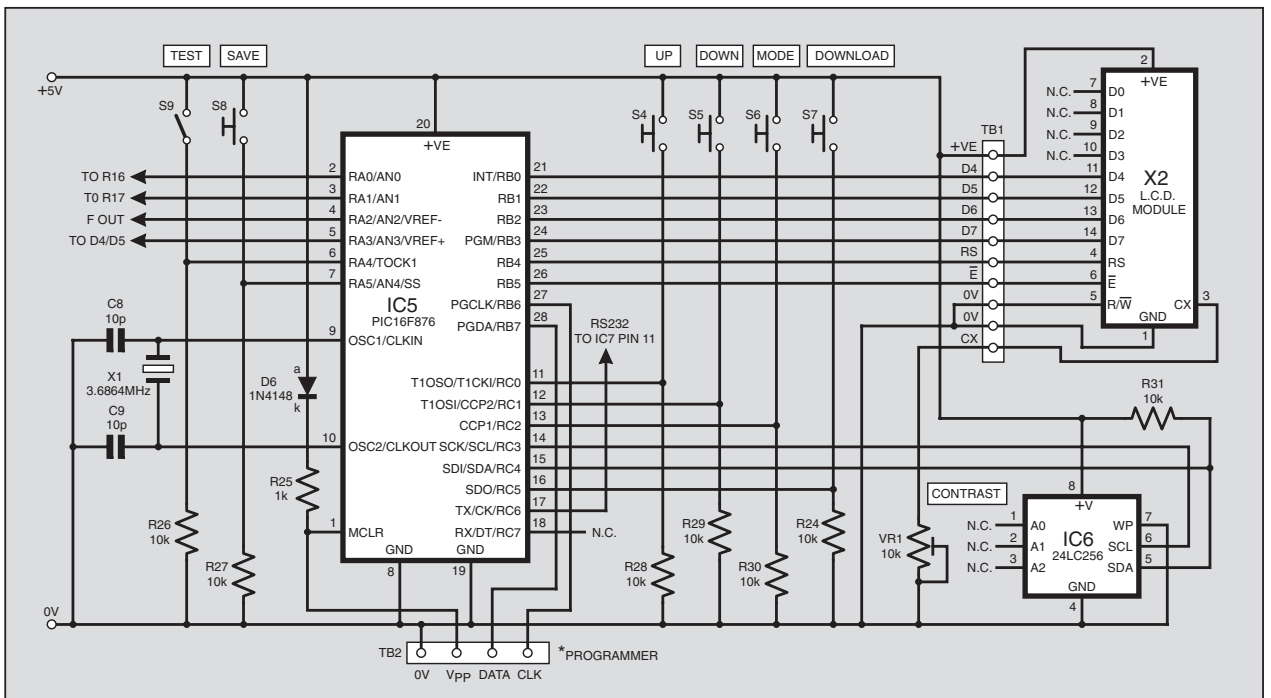


Fig.5. PIC-controlled processing, display and data storage circuit.



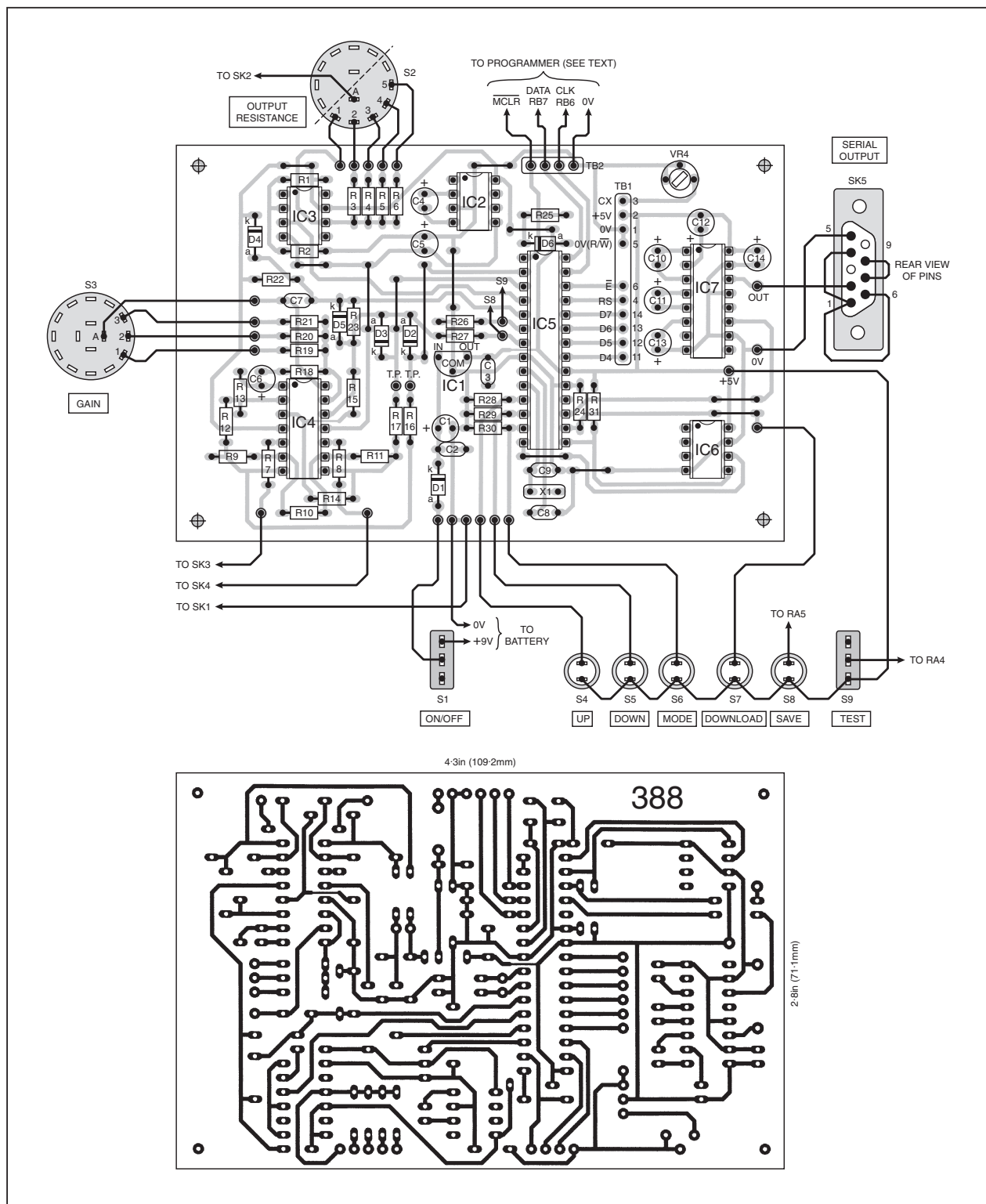


Fig.7. Printed circuit board component layout and full-size copper foil master track pattern for the Earth Resistivity Logger.

If you do not have VB6, you need three other files, **comdlg32.ocx**, **Mscmctl.ocx** and **Msxvb60.dll**, held on our 3.5-inch disk named Interface Disk 1, and in the Interface folder on the FTP site (they are also included with the *Toolkit TK3* software). These files must be copied into the same folder as the other Earth Resistivity files.

## CONSTRUCTION

Details of the component and track layouts for the printed circuit board (p.c.b.)

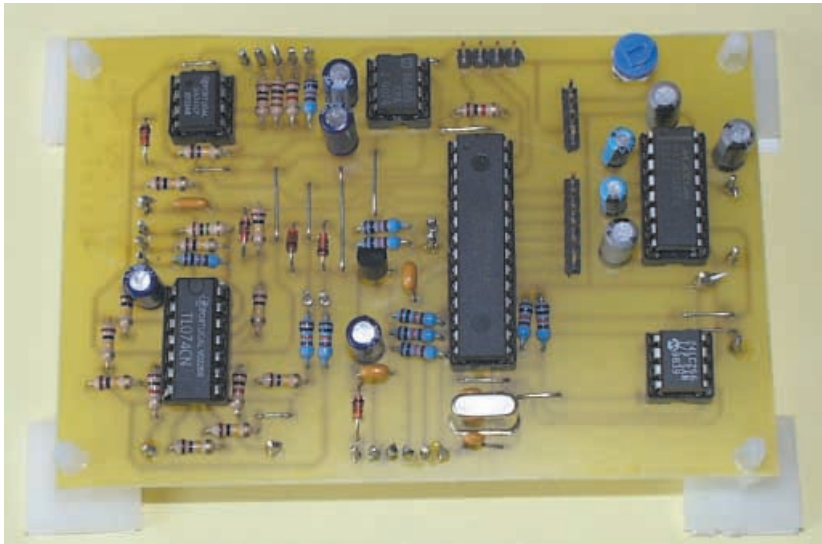
are shown in Fig.7. This board is available from the *EPE PCB Service*, code 388.

Assemble in any preferred order, ensuring that all the on-board link wires are included, and that all polarity-conscious components are the correct way round. The use of sockets for all the dual-in-line (d.i.l.) i.c.s is recommended; it is *essential* to use one for the PIC, IC5. Treat all i.c.s as static sensitive and discharge static electricity from yourself before handling them, by touching the bare grounded metal of an item of earthed equipment, for example.

Double-check the perfection of your soldering and component positioning before applying power. Do not insert any of the d.i.l. i.c.s until the correctness of the +5V output from regulator IC1 has been proved.

To provide a degree of waterproofness, the prototype was mounted in a robust plastic box with a see-through lid. The i.c.d. was mounted below the lid on the inside. If a metal box with a see-through lid can be found, it would provide even greater durability.





*The final prototype board prior to installation.*

It is recommended that a case of at least 50 per cent larger than used in the prototype should be employed to allow a large 9V to 12V battery to be adequately housed.

Probe sockets were 2mm types on the prototype, simply because the author had them in stock. It is recommended that 4mm types should be used. These provide greater robustness of the plugged connections and allow them to be removed readily. Nick recommends the use of restraints near the sockets to prevent the connections pulling out during a survey.

The probe sockets should be colour coded, as should their respective plugs. Colour suggestions are shown in the circuit diagrams of Fig.3 and Fig.4, but may be changed to suit availability. It is important NOT to duplicate the colours – doing so could result in leads being incorrectly allocated to probes.

The use of crocodile clips with colour-coded plastic covers was found to facilitate the connection of leads to the probes themselves. Heavy-duty crocodile clips are recommended for ease of use (especially in cooler or wet weather!).

When testing the prototype, it did not appear to matter whether the probe leads were screened or not. Consequently, standard lighting or low current cable could be used. Twin-core mains cable was used by the author and Nick, but in long term surveys it might prove more convenient to have a mix of cable arrangements, of

differing lengths and cores. Obviously the thicker it is, the lower the loss over long lengths, but 50m (say) of such cable is expensive, and heavy to drag about.

Details of constructing customised probes are given in Part 2, but in simple applications four thin metal rods of the type used in gardens as flower supports can be used.

## TESTING

Having established that +5V is present on the output of regulator IC1, plug in the voltage inverter chip, IC6, and check that around –5V is present on its output. Naturally, always disconnect power before making component changes.

If all is well, the remaining i.c.s can be inserted and the l.c.d. connected. Typical

pinouts for the latter are shown in Fig.8. It will probably be necessary to adjust its contrast using VR1 before a display will be seen.

With power switched on again, check that +5V and –5V are still present where they should be. Switch off immediately if they are not, and correct the cause of malfunction.

On line 1 of the l.c.d., the message “SOIL RESISTIVITY” will be displayed briefly before being replaced by some numerical values, with more on line 2.



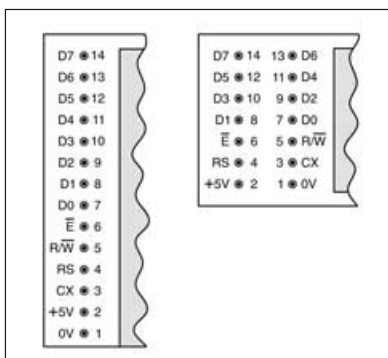
*L.C.D. display following switch-on.*



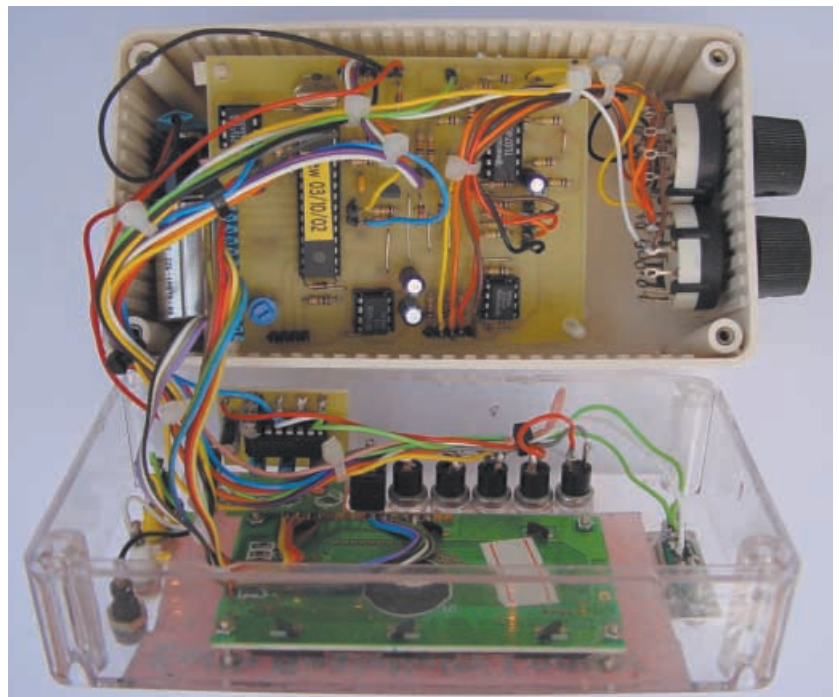
*Example display when carrying out soil monitoring with S9 switched on to test mode.*

With Test switch S9 switched on, the first two values on line 1 show the monitored values present at the outputs of IC4a/IC4b, as detected by the PIC's ADC conversions. Respectively, they are suffixed by the letters B and A, indicating the op.amp to which they refer (as given in the circuit diagram Fig.4).

With S9 off, the values are the upper and lower peak values resulting from the ADC conversion of the output of IC4d. They are suffixed by the letters H and L (High and Low). Any value between 0 and 1023 could appear at this time for all four readings.



*Fig.8. The two “standard” l.c.d. module pinout arrangements.*



*Interior of the case showing the relative positioning of the components. The p.c.b. is the first prototype which did not include the RS-232 device, IC7. The latter can be seen on its own sub-board to the left of the push-switches. It is recommended that a larger case is used to allow a heavier-duty battery to be inserted.*

At the top right of line 1 is another number, suffixed by a hash symbol (#). This is the processed value that, when Save switch S8 is pressed, is stored to the serial memory as a grid value for the coordinates on line 2. Switching between gain settings using S3, the value will change. (During a survey always keep S3 at the same setting.)

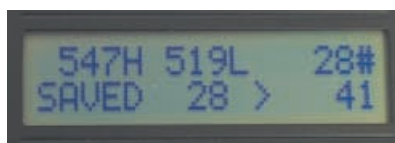
Note that if too strong an input signal is amplified, the op.amp's output may saturate (reach its maximum obtainable level). In practice, keep the value at the right of line 1 well below about 500. A value of 1023 is the maximum that can result from an ADC conversion, indicating that the ADC has received an input voltage equal to the power line voltage of +5V. This is an improbable event as the op.amp output is unlikely to swing that high.

## L.C.D. LINE 2

At the left of line 2 are shown the column and row values which represent the survey grid coordinates, and thus the location in the serial memory at which the processed IC4 value is stored. They are suffixed C and R respectively. An asterisk symbol (\*) will be seen to the right of one or the other of these coordinate values (more on setting coordinates in a moment).

At the right of line 2 is shown the value that is currently stored at the specified memory address. During the survey it will normally show 0 as each new coordinate is selected. When the Save switch S8 is pressed the display will change to repeat the number that has just been saved to the memory as a 2-byte value. At any time during the survey, the coordinate switches may be used to recall the values that are stored for each grid location.

There are three switches for coordinate setting. Two of them, S4 and S5, respectively increment or decrement the value beside which is shown the asterisk. The range is 0 to 127, rolling over to 0 after



Example of display when Save switch S8 is pressed. In this case saving 28 to EEPROM location 41.

incrementing beyond 127, or rolling over to 127 after decrementing below 0.

Pressing Mode switch S6 changes the position of the asterisk, thus allocating the +/- switches to that aspect of the grid, i.e. vertical (column) or horizontal (row).

## DATA TRANSFER SWITCH

Pressing Download switch S7 causes the PIC to send the contents of the serial memory to the PC at a rate of 9600 baud. As previously said, the values for each of the 16384 possible grid coordinates are stored as two bytes – the MSB and LSB of the 10-bit ADC values.

No attempt has been made to be selective about which set of values is sent to the PC. All 32768 values are sent on each occasion that S7 is pressed. The transfer takes about 30 seconds.

During transfer, the top l.c.d. line shows the message "SENDING TO PC", with line 2 blank. Upon completion of the transfer, line 2 shows "SENDING FINISHED", and line 1 briefly displays the "SOIL RESISTIVITY" message again, before clearing to once more show the values being sampled.

Line 2 remains with its last message shown until the asterisk (Mode) switch S6 is again pressed, to once more show the coordinate values.



Example display when downloading stored data to a PC-compatible computer has been completed.

Check that all the switches perform as intended. It is not necessary to have probes connected at this time, and it does not matter that the serial download will not be destined anywhere – the PC's data reception side of things will be covered in Part 2.

## PROGRAMMED ASIDE

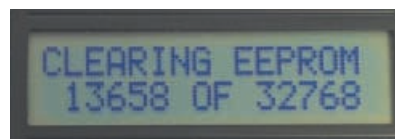
Incidentally, experiments were made using a graphics l.c.d. instead of an alphanumeric one, to see if survey data could be illustrated by the unit as an in-built 20 x 20 grid display. However, the

ability to display values as different intensity grey-scales was found to be too limited to justify the extra expense (at least another £30) and so the facility was dropped.

Had the result been acceptable, a PIC16F877 would have been used with the screen, in a manner similar to the author's *Using Graphics L.C.D.s with PICs* article of Jan '01.

## EEPROM RESETTNG

The contents of the serial EEPROM can be reset to zero when required. As a security measure (to avoid resetting inappropriately!), the reset routine can only be called at the moment that the power is being switched on. With the power off, press and hold down Save switch S8, then switch on the power. When the message CLEARING EEPROM is seen, release S8.



Example display during serial memory resetting.

On line 2 will be a progress count display as the software writes zeros to all 32768 EEPROM data locations. It is a somewhat lengthy process, taking about three and half minutes. This is due to numerous essential delays that are built into the writing procedure.

The software for the EEPROM writing and reading was originally downloaded from Microchip's CD-ROM for use in the PIC16F877 Data Logger referred to earlier. It is recommended that you do not attempt to modify Microchip's coding to speed the resetting process!

On completion of the resetting, which also resets the column and row values, the screen briefly shows the SOIL RESISTIVITY message and proceeds in the normal way as described earlier.

## NEXT MONTH

In the final part next month, the PC-compatible Windows software is described and probing methods discussed.



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Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

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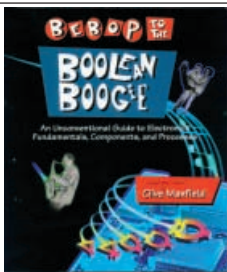
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None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

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During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' - blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirtieth birthday.

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R. A. Penfold

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There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

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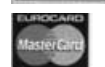
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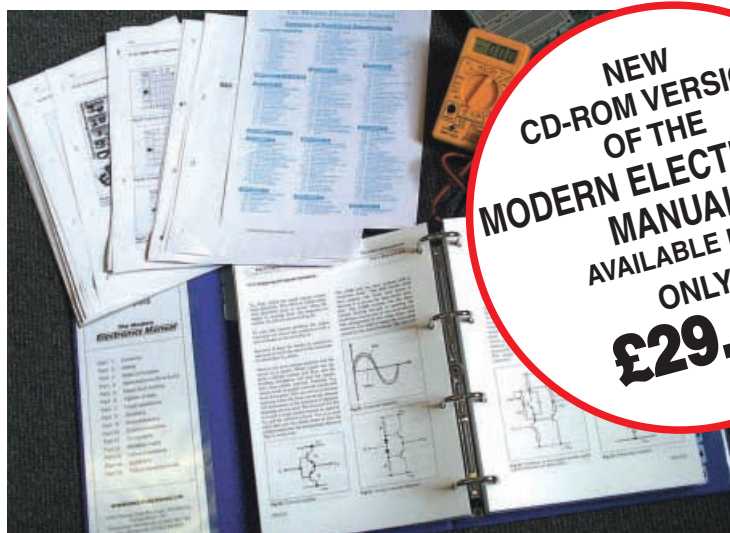
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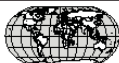
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